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Consumption Habits and Quality Perception of Potable Water in Culiacán, Sinaloa

Hábitos de Consumo y Percepción de la Calidad del Agua Potable de la Población de Culiacán, Sinaloa

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ABSTRACT

This work identifies the consumption habits and perceptions of the consumers about the drinking water quality in Culiacán, Sinaloa, Mexico. A questionnaire divided into three sections (socio-demographic information, consumption habits, and quality perceptions of potable water from the public network) was applied following the socioeconomic strata of the city during two periods that covered the four seasons of the year. The results were analyzed using descriptive statistical analysis and simple correspondence analysis. Results. The primary source of water supply for drinking and food preparation in households was obtained from local purification plants. 30 % of the population uses water from the public network to prepare food. Even though the color and smell of water from the public network were perceived as good, the population does not drink water directly from the public network. Conclusion. Consumption habits differ from the perception of water quality from the public network. The results provide primary information that, together with a subsequent quantitative microbiological risk assessment of tap water and jug water from purification plants in Culiacán, will allow the development of strategies to minimize health-related risks to water supplies.

KEY WORDS: Potable water, consumption, perception, quality, survey

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RESUMEN

Este trabajo identifica los hábitos de consumo y percepción de la calidad del agua potable de los consumidores de la ciudad de Culiacán, Sinaloa, México. Se aplicó un cuestionario bajo un esquema estratificado por niveles socioeconómicos, durante dos periodos que abarcaron las cuatro estaciones del año. Los resultados fueron analizados mediante análisis estadístico descriptivo y análisis de correspondencia simple para determinar asociación entre variables de interés. La principal fuente de abastecimiento de agua para beber y preparar alimentos en el hogar son garrafones obtenidos de plantas purificadoras locales. El 30 % de la población utiliza agua de la red pública para preparar alimentos; por otro lado, a pesar de que color y olor del agua de la red pública son percibidos como buenos, la población no bebe el agua directamente de la red pública. Conclusión. Los hábitos de consumo difieren de la percepción de la calidad del agua de la red pública en Culiacán. Los resultados obtenidos proveen información primaria que, en conjunto con un posterior análisis cuantitativo del riesgo microbiológico del agua de la red pública y agua de garrafón de plantas purificadoras en Culiacán, permitirán proponer estrategias y medidas para minimizar los riesgos relacionados con las principales fuentes de abastecimiento de agua.

PALABRAS CLAVE: Agua potable, consumo, percepción, calidad, encuesta.

Introduction

Water for human consumption must be potable; that is, colorless, odorless, and with no adverse health effects, to be considered appropriate for human use and consumption. Potable water is primarily used for domestic purposes (CONAGUA, 2014), and inadequate control during the supply process –from source to distribution– can lead to extensive contamination and cause disease outbreaks. Access to potable water is critical to maintaining health, whether it is used for drinking, household tasks, food preparation, or recreational activities (WHO, 2018). The main quality parameters include chemical, microbiological, physical, and radiological aspects, and it must not contain pollutant concentrations that exceed the permissible limits (DOF, 2022).

During rainy periods, water treatment plants face operational challenges due to the presence of turbid water from supply sources, which affects the quality of the treated water (CONAGUA, 2014). On the other hand, anthropogenic erosion activities such as industrial processes, domestic wastewater discharge, agricultural runoff, and soil erosion can affect the source supplying water treatment plants, which contributes to both point and non-point pollution (Ighalo *et al*., 2021;

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Montgomery, 2008). Chemical and microbiological contaminants are reduced in water treatment systems through filtration and disinfection products. However, distribution systems can still harbor indicator microorganisms such as *Escherichia coli* and pathogenic microorganisms such as *Salmonella* spp. and *Shigella* spp., as well as opportunistic pathogens such as *Pseudomonas* spp., *Staphylococcus* spp., and *Enterobacter* spp. These microorganisms pose a health risk to consumers because they can cause gastrointestinal, skin, ear, eye, respiratory, and other diseases (Kalu *et al*., 2024). In Culiacán, there have been reports of fecal indicator bacteria, as well as opportunistic pathogens such as *P. aeruginosa* in the water of the public distribution network (Chaidez *et al*., 2008).

When it comes to potable water quality, consumers perceive its properties through their senses (WHO, 2018), by a cognitive process that involves different levels of subjective interpretation of reality and can be influenced by learning, memory, and symbolization. This perceptual process allows us to recognize, interpret, and give meaning to sensations from the physical and social environment (Vargas Melgarejo, 2014). Therefore, the perception of water quality results from a complex interaction of various factors such as climate, socioeconomic level, customs, trust in operating systems, convenience of acquisition and consumption, and organoleptic preferences (Faviel-Cortez *et al*., 2019; Gonzales-Villareal *et al*., 2016; Marquez-Fernandez & Ortega-Marquez, 2017). A perception study can be conducted using well-designed questionnaires that collect data on attitudes, interests, value judgments, knowledge, behavior, and demographic and socioeconomic characteristics of consumers (Marquez-Fernandez & Ortega-Marquez, 2017).

According to the Households and Environment Module (MOHOMA, Spanish acronym) of the National Institute of Statistics and Geography (INEGI, Spanish acronym), the primary source of drinking water in Mexico is from jugs or bottled water (76.3 %), with only 19.30 % of the population drinking water from the public supply (INEGI, 2018). The low consumption of water from the public network is mainly because the Mexican population considers water from the public network to be unhealthy and does not like its taste and color (Espinosa-Garcia *et al*., 2015; González Villarreal *et al*., 2016; INEGI, 2018; Rubino *et al*., 2018).

This study aimed to understand the habits, quality perceptions, and negative impacts experienced by the population when consuming drinking water from the public distribution system in the city of Culiacán.

Materials and Methods

Study Area

This study was conducted in the city of Culiacán, Sinaloa, Mexico, located between the meridians 106° 56’ 50” and 107° 50’ 15” W, and at the extreme coordinates of latitude 24° 02’ 10” and 25° 14’ 56” N. The weather condition in Culiacán is predominantly dry and warm, with an average annual temperature of 27 °C, rainfall from June to October, and dry spells from September

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to May, with an average annual rainfall of 682.7 mm. The city covers an urban area of 17,651 hectares (CONAGUA, 2014), with a population of 808,416 inhabitants and 281,567 inhabited dwellings, according to the 2020 census (INEGI, 2021).

The Municipal Board of Potable Water and Sewerage of Culiacán (JAPAC, Spanish acronym) manages the city's water supply, operating four rapid filtration water treatment plants using conventional technology, patented technology (Pelletier type), and local technology (actifangos type). These plants carry out the stages of coagulation (flocculation), sedimentation, rapid filtration, and chlorination for disinfection (JAPAC, 2025). Surface water from the Humaya, Tamazula, and Culiacán rivers and the San Lorenzo canal supplies these plants (CONAGUA, 2014), accounting for 80% of the potable water used in the city (JAPAC, 2025). JAPAC covers 99.45% of the city's tap water needs through a distribution system with 18 regulation tanks (50,370 m³ capacity) and a 3,364 km long network (CONAGUA, 2014).

The daily domestic consumption of potable water in Culiacán is between 168 and 189 liters per person, fluctuating greatly due to high temperatures during dry periods, impacting the demand of different socioeconomic groups in their residential areas (CONAGUA, 2014).

In addition, there are 454 registered establishments dedicated to the purification and sale of bottled water in Culiacán (Figure 1) (INEGI, 2024). These facilities use sieve filters, deep bed filters, polishing filters, UV light lamps, and ozone to reduce or eliminate water contaminants.

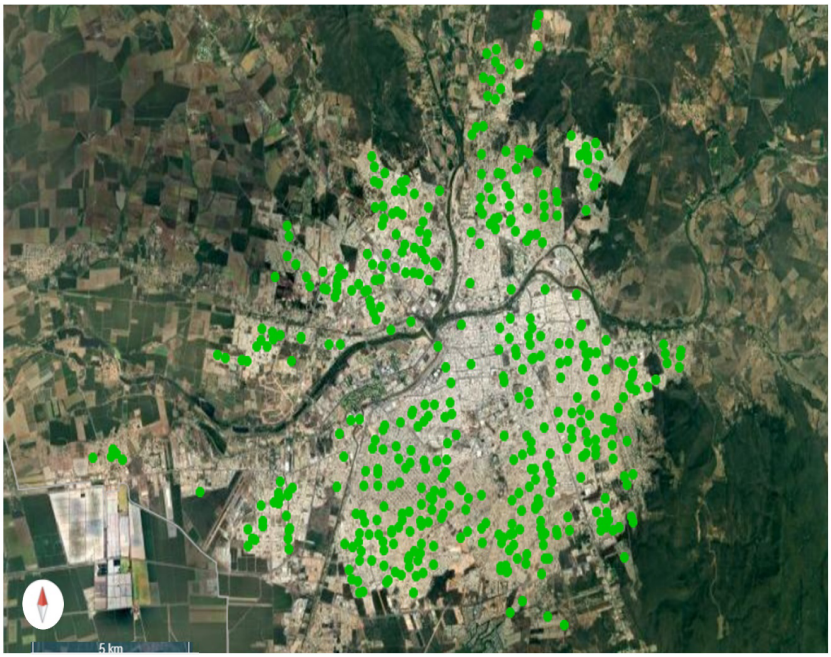

Figure 1. Purification and bottling of water facilities in the urban area of Culiacán.

Source: INEGI (2024).

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Survey Questionnaire

Households were selected as the units of study, and relevant information was collected using a questionnaire divided into three sections: The first section addresses socio-demographic information from the population at the places where the dwelling is located. The second section covers consumption habits: water types used for food preparation and drinking, including water from local purification plants, commercially bottled purified water, potable water from the public network, and potable water treated with a home filter. Multiple choice questions were used, and questions were asked about the sources of purified water supply, daily water consumption of drink water, use of dispensers, and types of water filters (including reverse osmosis, activated carbon, ozone, or ultraviolet light). The third section includes consumers' perceptions of water quality (color, smell, and health confidence), the presence of pollutants (chemical and microbiological), and association with gastrointestinal, skin, ear, and eye diseases among household members due to consumption or contact with water distributed via the public network. To adjust the questionnaire, a pilot study was conducted with 50 questionnaires, covering households from low, middle, and high socioeconomic strata. After the pilot test, the final questionnaire was adapted to 12 questions.

Survey

The sample size was determined using the equation of Reyes *et al*. (2013) as follow:

$$n = \frac{Z^2\, p(1-p)}{E^2} \qquad \text{(Equation 1)}$$

where n is the desired sample size, z is the critical value under the given significance level, p is the proportion to be estimated, and E is the estimation error. Assuming a conservative approach with p = 0.5, estimation error E = 0.05, and a 95% confidence level (z = 1.96), the number of households to be surveyed is

$$n = \frac{(1.96)^2\ (0.5)(1-0.5)}{(0.05)^2} \approx 385.$$

Four hundred households were surveyed in three stages. First, using sociodemographic indicators from INEGI (2020), 576 neighborhoods in Culiacán were identified and classified into low, medium, and high socioeconomic strata, resulting in 43 (p_{HL} = 0.075) high-stratum neighborhoods, 198 (p_{ML} = 0.340) middle-stratum neighborhoods, and 335 (p_{LL} = 0.582) low-stratum neighborhoods. Second, 50 neighborhoods in the city were randomly selected based on the proportions from the first stage, resulting in 29 low-stratum neighborhoods, 17 medium-stratum neighborhoods, and 4 high-stratum neighborhoods (Figure 2). Third, each neighborhood was stratified by blocks, and the number of households was determined based on the number of households per stratum (6,551 households at the high-stratum, 11,398 households at the medium-stratum, and 21,537 households at the low-stratum), sample size was calculated (400), resulting in 67 households at the high-stratum, 115 at the medium-stratum, and 218 at the low-stratum.

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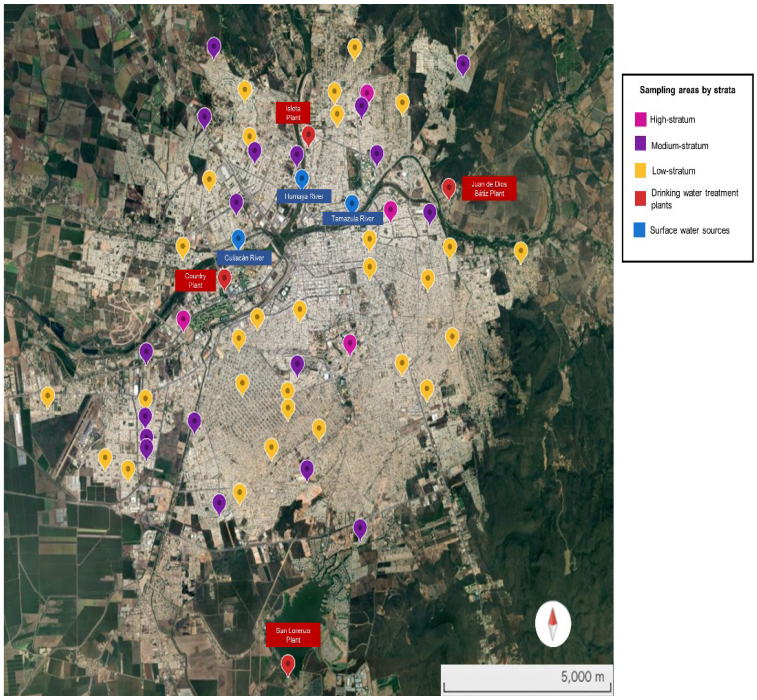

Figure 2. Sampling Areas by Socioeconomic Level.

Source: own elaboration.

In each household sampled, the questionnaire was applied face-to-face with an adult who was responsible for food preparation at home and knew about the place of purchase of consumed water. This study was approved by the Research Ethics Committee of the Research Center in Food and Development (CIAD, Spanish acronym), and participants provided written informed consent to participate. A survey was administered between February and October 2024 and covered the winter-spring period (February to March 2024) and the summer-autumn period (August to October 2024). Completing the questionnaire took between 12 and 15 minutes.

Statistical Analysis

The sociodemographic characteristics, consumption habits, and perception of the water quality were interpreted through descriptive statistical analysis and simple correspondence analysis to determine relationships between variables of interest. Data were processed using Minitab 19 (Minitab, LLC. Minitab Statistical Software, State College, PA, USA).

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Results and Discussion

Consumption Habits

During the period under study, jug water was the primary type of water used for drinking and food preparation in the three socioeconomic levels. Commercially branded bottled water was used primarily for drinking and less often for food preparation. Bottled water consumption was similar across all three socioeconomic levels; however, high-stratum used more commercially branded bottled water for food preparation, whereas low-stratum used it less often (Table 1).

Filtered water was the least used type of water for both food preparation and drinking, with usage varying by socioeconomic strata. Filtered water was used more at high-stratum and less frequently at low-stratum. Water from the public network was used exclusively for food preparation, showing a very similar pattern at all socioeconomic strata, and was not used for drinking at any strata (Table 1).

Purified water consumed came mainly from local purification plants, which were the most used by low-stratum. The second leading source of purchases was the delivery trucks of local purification plants, with high and medium strata using these services more frequently. Finally, commercially branded water was the least consumed, with high and medium strata being the primary consumers (Table 1).

Drinking water consumption in the sample ranged between 1 and 2 liters per day, with an increase to more than 2 liters per day in the summer-autumn period compared to the winter-spring period (Table 1).

The high-stratum used the most filters to purify drinking water, while the low-stratum had less frequent use (Table 1).

Association Between Consumption Habits, Socioeconomic Strata, and Water Types

The relationship between consumption habits, socioeconomic strata, and water types was determined through simple correspondence analysis (Table 2, Figure 3). Bottled water and jug water were the primary sources of drinking water. High and medium strata tended to prefer bottled water, while low-stratum preferred jug water. For food preparation, jug water, filtered water, and water from the public network were used, with low-stratum being most associated with using water from the public network for this activity. All socioeconomic strata used jug water both for food preparation and drinking.

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Table 1. Frequencies of drinking water consumption in Culiacán across the three stratification levels during the application periods.

Habits	Presentation	Winter-Spring			Summer-Autumn		
		Socioeconomic Stratum			Socioeconomic Stratum		
		High (**67**)	Medium (**115**)	Low (**218**)	High (**67**)	Medium (**115**)	Low (**218**)
Food preparation water	Commercially branded bottled water	**22**(32.84%)	**20**(17.39%)	**24**(11.01%)	**13**(19.40%)	**16**(13.91%)	**27**(12.39%)
	Jug water	**63**(94.03%)	**104**(90.43%)	**198**(90.83%)	**64**(95.52%)	**105**(91.30%)	**199**(91.28%)
	Public network	**19**(28.36%)	**31**(26.96%)	**67**(30.73%)	**22**(32.84%)	**42**(36.52%)	**82**(37.61%)
	Water filter	**6**(8.96%)	**5**(4.35%)	**8**(3.67%)	**8**(11.94%)	**10**(8.70%)	**6**(2.75%)
Drinking water	Commercially branded bottled water	**34**(50.75%)	**53**(46.09%)	**72**(33.03%)	**37**(55.22%)	**56**(48.70%)	**95**(43.58%)
	Jug water	**63**(94.03%)	**102**(88.70%)	**211**(96.79%)	**64**(95.52%)	**107**(93.04%)	**213**(97.91%)
	Public network	**0**(0%)	**0**(0%)	**0**(0%)	**0**(0%)	**0**(0%)	**0**(0%)
	Water filter	**3**(4.48%)	**4**(3.48%)	**6**(2.75%)	**7**(10.45%)	**10**(8.70%)	**4**(1.83%)
Point of purchase of purified water	Commercially branded bottled water	**18**(26.87%)	**10**(8.70%)	**6**(2.75%)	**9**(13.43%)	**19**(16.52%)	**9**(4.13%)
	Local Purification Plant	**40**(59.70%)	**68**(59.13%)	**186**(85.32%)	**32**(47.76%)	**68**(59.13%)	**184**(84.40%)
	Distributor Truck of Local Purification Plants	**16**(23.88%)	**36**(31.30%)	**27**(12.39%)	**23**(34.33%)	**28**(24.35%)	**25**(11.47%)

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Continuation

Table 1. Frequencies of drinking water consumption in Culiacán across the three stratification levels during the application periods.

Habits	Presentation	Winter-Spring			Summer-Autumn		
		Socioeconomic Stratum			Socioeconomic Stratum		
		High (**67**)	Medium (**115**)	Low (**218**)	High (**67**)	Medium (**115**)	Low (**218**)
Daily drinking water consumption	Less than 1 liter	**20**(29.85%)	**8**(6.96%)	**22**(10.09%)	**6**(8.96%)	**13**(11.30%)	**13**(5.96%)
	From 1 to 2 liters	**33**(49.25%)	**67**(58.26%)	**130**(59.63%)	**37**(55.22%)	**55**(47.83%)	**118**(54.13%)
	More than 2 liters	**14**(20.90%)	**40**(34.78%)	**66**(30.28%)	**24**(35.82%)	**47**(40.87%)	**87**(39.91%)
Water filter installed in the household	Yes	**6**(8.96%)	**5**(4.35%)	**8**(3.67%)	**8**(11.94%)	**10**(8.70%)	**6**(2.75%)
	No	**61**(91.04%)	**110**(95.65%)	**218**(96.33%)	**59**(88.06%)	**105**(91.30%)	**212**(97.25%)

Source: own elaboration.

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Table 2. Contingency Table. Simple Correspondence Analysis. Association between Consumption Habits, Water Types, and Socioeconomic Strata.

	Commercially branded bottled water	Jug water	Water filter	Water from the public network	Total
Foodprep_High	35	127	14	41	217
Foodprep_Medium	36	209	15	73	333
Foodprep_Low	51	397	14	149	611
Drinking_High	71	127	10	0	208
Drinking_Medium	109	209	14	0	332
Drinking_Low	167	424	10	0	601
Total	469	1493	77	263	2302

Foodprep: food preparation. Source: own elaboration.

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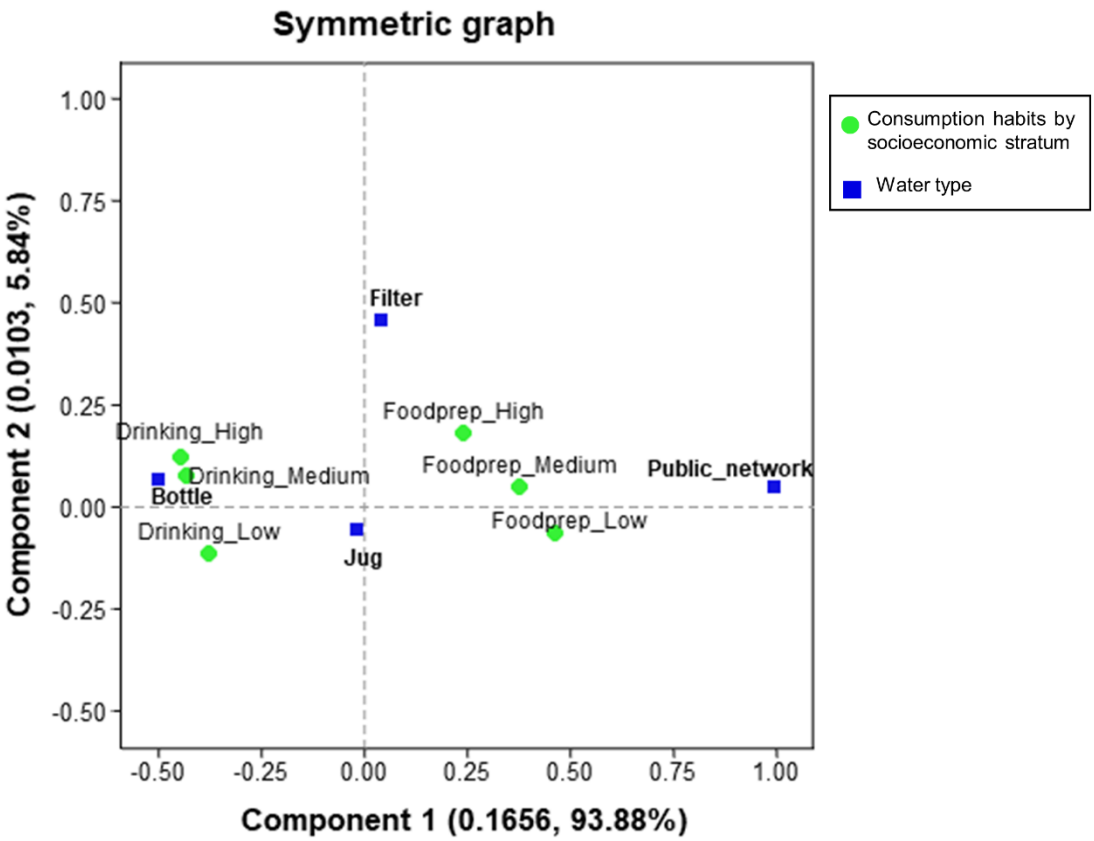

Figure 3. Simple Correspondence Analysis. Association between Consumption Habits, Types of Water, and Strata.

Source: own elaboration.

Association Between Consumption Habits, Water Types, and Survey Application Period

The relationship between consumption habits, water types, and the survey application period was determined through simple correspondence analysis (Table 3, Figure 4). Bottled and jug water were the primary sources of drinking water during both survey application periods. Additionally, jug water, filtered water, and water from the public network water were used during both application periods for food preparation.

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Table 3. Contingency Table. Simple Correspondence Analysis. Association between Consumption Habits, Types of Water, and Survey Application Periods.

	Commercially branded bottled water	Jug water	Water filter	Water from the public network	Total
Foodprep_WS	66	365	19	117	567
Foodprep_SA	56	368	24	146	594
Drinking_WS	159	376	13	0	548
Drinking_SA	188	384	21	0	593
Total	469	1493	77	263	2302

Foodprep: food preparation; WS: winter-spring period; SA: summer-autumn period.

Source: Own elaboration.

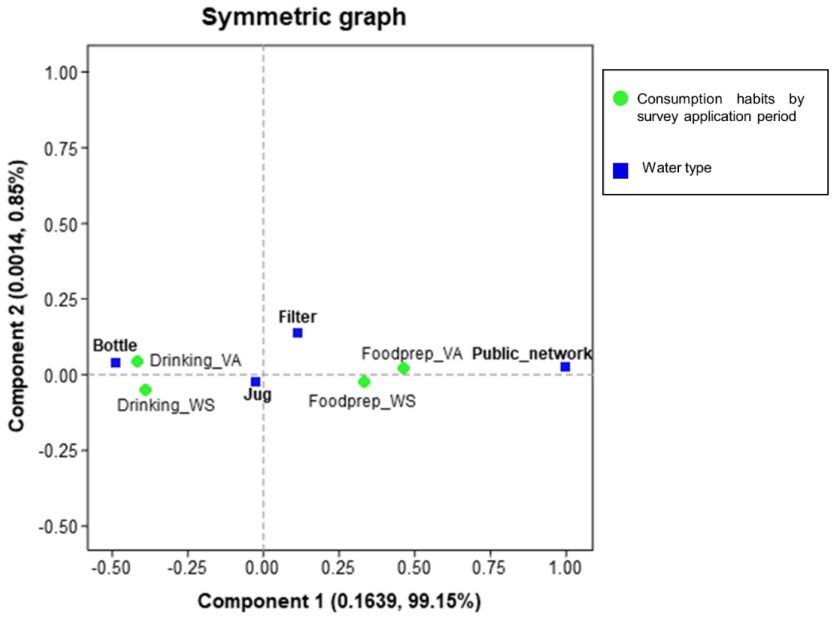

Figure 4. Simple Correspondence Analysis. Association between Consumption Habits, Types of Water, and Survey Application Periods. Foodprep: food preparation; WS: winter-spring period; SA: summer-autumn period.

Source: own elaboration.

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Perception of the Quality of Water from the Public Network

The population considered that color and smell of water from public network was good, but with a regular confidence perception regarding health. There was a high level of concern about the presence of chemical contamination, with people at all three socioeconomic strata being worried. Likewise, the population was mainly concerned about microbiological contamination, but in this case, the medium-stratum was most concerned (Table 4).

Association between Water Quality of the Public Water Network and Socioeconomic Strata

The relationship between the perception of public water network quality and socioeconomic level is shown in Table 5 and Figure 5. Color and smell showed a connection with positive perceptions across all strata, ranging from good to very good. Confidence regarding health was grouped under negative perceptions, being considered regular, bad, and very bad at the three socioeconomic strata.

Association between the Water Quality of the Public Network and Survey Application Periods

The relationship between the perception of the water quality of the public network and survey application periods is shown in Table 6 and Figure 6. Color and smell were positively associated with all strata, being rated from good to very good in both survey application periods. Health Confidence was grouped into negative perceptions, being considered regular, bad, and very bad across in both survey application periods.

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Table 4. Perception of Quality and Concern about the Presence of Microbiological and Chemical Contamination in Water from the Public Network.

Attributes	Perception	Winter-Spring			Summer-Autumn		
		Socioeconomic Stratum			Socioeconomic Stratum		
		High (**67**)	Medium (**115**)	Low (**218**)	High (**67**)	Medium (**115**)	Low (**218**)
Color	Very bad	**0**(0%)	**5**(4.35%)	**0**(0%)	**3**(4.48%)	**3**(2.61%)	**5**(2.29%)
	Bad	**8**(11.94%)	**2**(1.74%)	**11**(5.05%)	**5**(7.46%)	**2**(1.74%)	**13**(5.96%)
	Regular	**17**(25.37%)	**27**(23.48%)	**64**(29.36%)	**18**(26.87%)	**37**(32.17%)	**55**(25.23%)
	Good	**30**(44.78%)	**65**(56.52%)	**93**(42.66%)	**35**(52.24%)	**53**(46.09%)	**110**(50.46%)
	Very good	**12**(17.91%)	**16**(13.91%)	**50**(22.94%)	**6**(8.96%)	**20**(17.39%)	**35**(16.06%)
Smell	Very bad	**0**(0%)	**2**(1.74%)	**0**(0%)	**3**(4.48%)	**0**(0%)	**6**(2.75%)
	Bad	**4**(5.97%)	**6**(5.22%)	**13**(5.96%)	**0**(0%)	**14**(12.17%)	**10**(4.59%)
	Regular	**17**(25.37%)	**34**(29.57%)	**67**(30.73%)	**32**(47.76%)	**43**(37.39%)	**68**(31.19%)
	Good	**34**(50.75%)	**59**(51.30%)	**96**(44.04%)	**24**(35.82%)	**39**(33.91%)	**108**(49.54%)
	Very good	**12**(17.91%)	**14**(12.17%)	**42**(19.27%)	**8**(11.94%)	**19**(16.52%)	**26**(11.93%)
Confidence regarding health	Very bad	**7**(10.45%)	**8**(6.96%)	**16**(7.34%)	**6**(8.96%)	**9**(7.83%)	**15**(6.88%)
	Bad	**8**(11.94%)	**15**(13.04%)	**25**(11.47%)	**2**(2.99%)	**21**(18.26%)	**39**(17.89%)
	Regular	**26**(38.81%)	**52**(45.22%)	**78**(35.78%)	**38**(56.72%)	**48**(41.74%)	**84**(38.53%)
	Good	**18**(26.87%)	**26**(22.61%)	**68**(31.19%)	**19**(28.36%)	**28**(24.35%)	**58**(26.61%)
	Very good	**8**(11.94%)	**14**(12.17%)	**31**(14.22%)	**2**(2.99%)	**9**(7.83%)	**22**(10.09%)
Concern about microbiological contamination	Not concerned	**11**(16.42%)	**12**(10.43%)	**32**(14.68%)	**7**(10.45%)	**4**(3.48%)	**17**(7.80%)
	Somewhat concerned	**26**(38.81%)	**37**(32.17%)	**69**(31.65%)	**21**(31.34%)	**39**(33.91%)	**80**(36.70%)
	Concerned	**19**(28.26%)	**60**(52.17%)	**73**(33.49%)	**31**(46.27%)	**48**(41.74%)	**75**(34.40%)
	Very concerned	**11**(16.42%)	**6**(5.22%)	**44**(20.18%)	**8**(11.94%)	**24**(20.87%)	**46**(21.10%)
Concern about chemical contamination	Not concerned	**4**(5.97%)	**16**(13.91%)	**27**(12.39%)	**7**(10.45%)	**6**(5.22%)	**13**(5.96%)
	Somewhat concerned	**18**(26.87%)	**22**(19.13%)	**56**(25.69%)	**23**(34.33%)	**35**(30.43%)	**68**(31.19%)
	Concerned	**30**(44.78%)	**57**(49.57%)	**84**(38.53%)	**20**(29.85%)	**44**(38.26%)	**80**(36.70%)
	Very concerned	**15**(22.39%)	**20**(17.39%)	**51**(23.39%)	**17**(25.37%)	**30**(26.09%)	**57**(26.15%)

Source: own elaboration.

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Table 5. Contingency Table. Simple Correspondence Analysis. Association between Perception of the Water Quality of the Public Network and Socioeconomic Strata.

	Very bad	Bad	Regular	Good	Very good	Total
Color_High	3	13	35	65	18	134
Color_Medium	8	4	64	118	36	230
Color_Low	5	24	119	203	85	436
Smell_High	3	4	49	58	20	134
Smell_Medium	2	20	77	98	33	230
Smell_Low	6	23	135	204	68	436
Health_High	13	10	64	37	10	134
Health_Medium	17	36	100	54	23	230
Health_Low	31	64	162	126	53	436
Total	88	198	805	963	346	2400

Source: own elaboration.

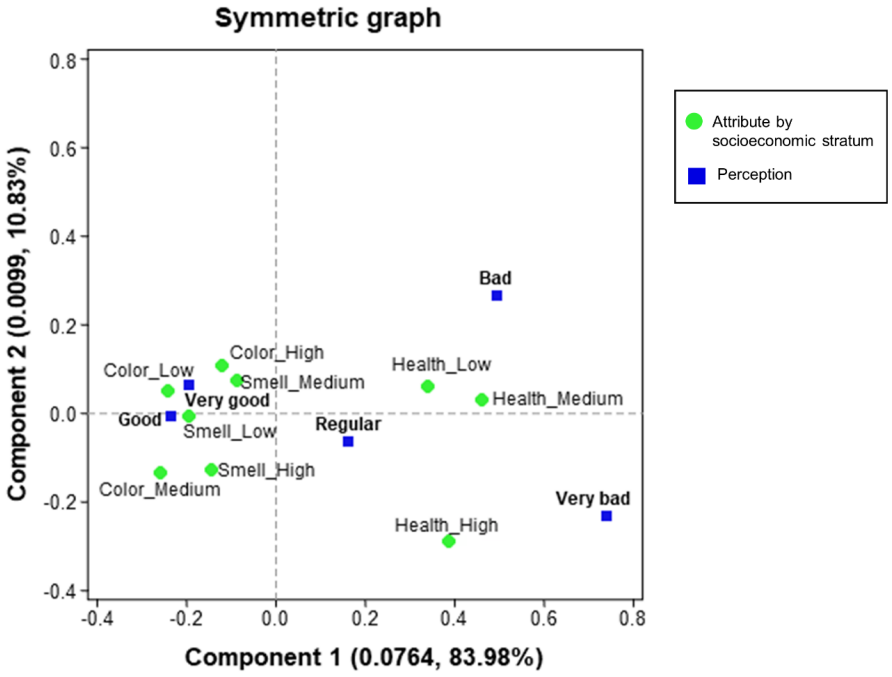

Figure 5. Simple Correspondence Analysis. Association between the Perception of Water Quality of the Public Network and Socioeconomic Strata.

Source: own elaboration.

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Table 6. Contingency Table. Simple Correspondence Analysis. Association between the Perception of Water Quality of the Public Network and Survey Application Periods.

	Very bad	Bad	Regular	Good	Very good	Total
Color_WS	5	21	108	188	78	400
Color_SA	11	20	110	198	61	400
Smell_WS	2	23	118	189	68	400
Smel_SA	9	24	143	171	53	400
Health_WS	31	48	156	112	53	400
Health_SA	30	62	170	105	33	400
Total	88	198	805	963	346	2400

WS: winter-spring period; SA: summer-autumn period.

Source: Own elaboration.

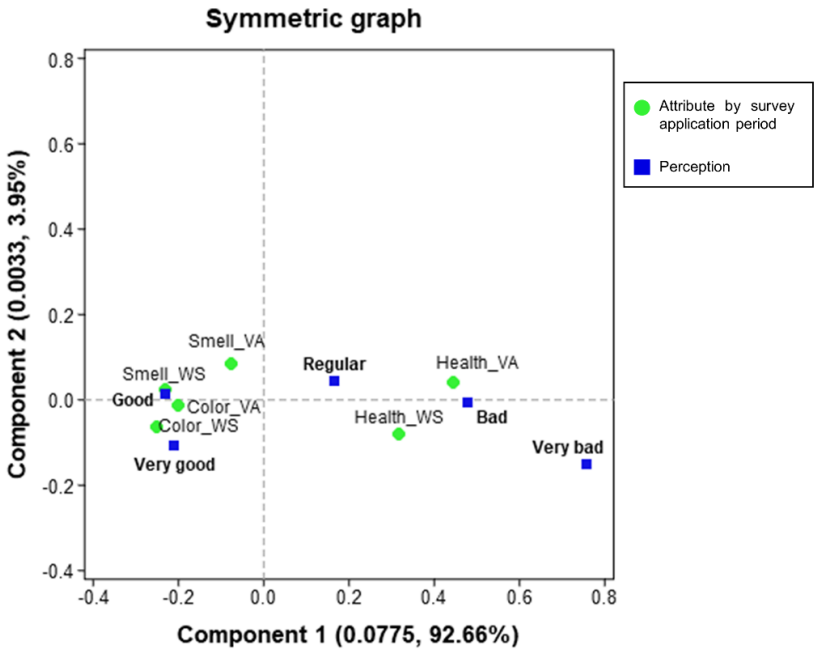

Figure 6. Simple Correspondence Analysis. Association between the Perception of Water Quality of the Public Network and Survey Application Periods. WS: winter-spring period; SA: summer-autumn period.

Source: own elaboration.

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Perception of Health Effects Due to Water from the Public Network

From the surveyed households, 36.63 % reported having suffered from some illness due to water consumption from the public network, with an increase of 10 % in the summer-autumn period. Gastrointestinal diseases were mentioned most frequently, followed by skin diseases, being more pronounced at high and low strata. Eye diseases occur third, with medium and low strata reporting these diseases more frequently. Finally, ear diseases were the least likely to be mentioned, with the low stratum reporting them more frequently in both application periods (Table 7).

Table 7. Adverse Health Effects Due to Water from the Public Network.

Disease	Winter-Spring			Summer-Autumn		
	Socioeconomic Stratum			Socioeconomic Stratum		
	High (**67**)	Medium (**115**)	Low (**218**)	High (**67**)	Medium (**115**)	Low (**218**)
Gastrointestinal	**13**(19.40%)	**28**(24.35%)	**55**(25.23%)	**16**(23.88%)	**29**(25.22%)	**73**(33.49%)
Skin	**13**(19.40%)	**8**(6.96%)	**21**(9.63%)	**9**(13.43%)	**14**(12.17%)	**41**(18.81%)
Eye	**3**(4.48%)	**5**(4.35%)	**17**(7.80%)	**2**(2.99%)	**12**(10.43%)	**15**(6.88%)
Ear	**0**(0%)	**4**(3.48%)	**15**(6.88%)	**1**(1.49%)	**3**(2.61%)	**11**(5.05%)

Source: own elaboration.

Association Between the Perception of Health Effects Due to Water from the Public Network, Socioeconomic Strata, and Questionnaire Application Periods

The relationship between the perception of adverse health effects due to water from the public network, socioeconomic strata, and questionnaire application period is shown in Table 8 and Figure 7. Skin diseases were associated with the high-stratum in both questionnaire application periods and the low-stratum during the summer-autumn application period. Eye and ear diseases were associated with the medium-stratum in both questionnaire application periods and the low-stratum during the winter-spring period. On the other hand, gastrointestinal diseases were associated with all three socioeconomic strata in both questionnaire application periods.

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Table 8. Contingency Table. Simple Correspondence Analysis. Association between the Perception of Health Effects Due to Water from the Public Network, Socioeconomic Strata, and Application Periods.

	Gastrointestinal	Skin	Eye	EASR	Total
High_WS	13.000	13.000	3.000	0.000	29.000
High_SA	16.000	9.000	2.000	1.000	28.000
Medium_WS	28.000	8.000	5.000	4.000	45.000
Medium_SA	29.000	14.000	12.000	3.000	58.000
Low_WS	55.000	21.000	17.000	15.000	108.000
Low_SA	73.000	41.000	15.000	11.000	140.000
Total	214.000	106.000	54.000	34.000	408.000

WS: winter-spring period; SA: summer-autumn period.
Source: Own elaboration.

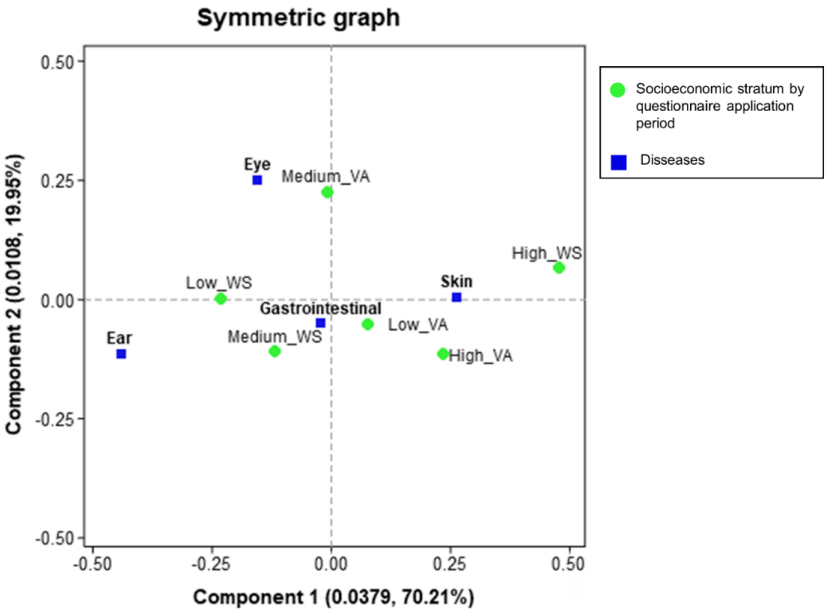

Figure 7. Simple Correspondence Analysis. Association between the Perception of Health Effects Due to Water from the Public Network and Socioeconomic Strata. WS: winter-spring period; SA: summer-autumn period.

Source: own elaboration.

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Mexico has one of the highest bottled water consumption rates in the world (Montero-Contreras, 2019). In addition to drinking and food preparation, bottled water is also used for cleaning household utensils and oral hygiene (Victory *et al*., 2022). Households in Culiacán primarily used water from local purification plants for drinking and preparing food at home. Commercial bottled water was rarely used, and when consumed, it was primarily for drinking, and very few households used it for food preparation. Regarding water filters, filtered water consumption was low because few households have these devices, with high-stratum households having the largest number of these devices. Finally, the consumption of water from the public network was low because only a few households used this water to prepare food.

Regarding water quality, the population rated the smell and color of the water from the public network as good; however, this assessment is subjective since the households surveyed do not use any technical criteria or specific tools to distinguish the characteristics of water from the public network. In general, the perception of water quality of the public network in Culiacán differed from consumption habits since the consumption of water from the public network was sporadic.

According to Gonzales-Villareal *et al*. (2016), perceptions of water quality variy between different socioeconomic levels, with high level having a better perception of the service. However, in the case of Culiacán, no differences were found in the perception of the water quality of the public network between the socioeconomic levels.

Commercially, consumers purchase water from establishment that specialize in purification and bottling, even though they assume that the water from the public network has good organoleptic quality. The increase in bottled water consumption is likely to be largely due to by consumers' distrust of supply systems, as they believe that water from the public network can cause illness in household members, and they are concerned about microbiological and chemical contamination. However, recent studies have shown that water from purification plants does not always meet microbiological quality guidelines (Venegas *et al*., 2022). Nevertheless, the consumption of bottled water from purification plants is very high, and the population continues to distrust water from the public network, so its use for human consumption in households is rare.

Conclusions

There was a contrast between the perception of the quality of water distributed through the public network and the drinking water consumption habits of residents of the Culiacán urban area. The population considered the color and smell of tap water in households was good; however, they were concerned about the presence of microbiological and chemical contaminants in the water from the public network and had no confidence in potable water to drink it. In addition, it was believed that water from the public network had caused gastrointestinal illnesses in household members, so they do not drink water from the public network, and only 30% of households used it for food preparation. Finally, the main water source for drinking and food preparation was jug water from local purification plants.

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The results obtained in this study provide primary information on consumption habits and the estimation of water intake in the population, which, together with a subsequent quantitative analysis of the microbiological risk of water from public networks and bottled water from purification plants in Culiacán, form the basis for the proposal of strategies and measures to minimize the risks associated with the main sources of water supply in households.

Author Contributions

Conceptualization of the work, C.C.S.A., C.C., J.B.V.T.; development of the methodology, C.C.S.A., J.B.V.T.; software management, C.C.S.A., J.B.V.T.; experimental validation, C.C.S.A., J.B.V.T.; result analysis, C.C.S.A., J.B.V.T., C.C., N.C.C., P.J.B.B., C.H.Z.; data management, C.C.S.A., J.B.V.T.; manuscript writing and preparation, C.C.S.A.; drafting, review, and editing, C.C.S.A., J.B.V.T., C.C., N.C.C., P.J.B.B., C.H.Z.; funding acquisition, C.C, N.C.C.

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Ethical Statements

This research has the approval of the “Research Ethics Committee of CIAD.”

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Conflict of interest

The authors declare no conflict of interest.

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