TECHNIUM

Technium Vol. 10, pp.74-86 (2023)
ISSN: 2668-778X
www.techniumscience.com

Social perception of the effects of high manganese concentrations in drinking water in households in the municipality of Guasave, Sinaloa, Mexico.

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Abstract. The groundwater of the Sinaloa River valley plays an important role in the water supply for domestic activities in the municipality of Guasave, Sinaloa Mexico, since the supply comes from wells and is provided to the population through the distribution pipe system. The municipal authorities have recognised that these waters contain different concentrations of manganese, which can cause health problems in the population. Therefore, the aim of this study is to explore the public's perception of the harm caused by manganese in the households as a consequence of the use of water with high levels of this metal in domestic activities. The results indicate that although 51.69% of the users are unaware of the presence of manganese in their homes, they have noticed its repercussions, such as in water deposits, toilets and clothing. Also, they have observed blockages, mainly in electric showers (51.05%) and in water pipes (38.13%), and 29.75% have noticed undesirable tastes and colors in the water. Ninety-nine percent of respondents indicated that they prefer to buy bottled (purified) water for consumption because of the confidence it provides.

Keywords. Pipe blockages, sanitary risk, groundwater.

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1. Introduction

The issue of water scarcity is relevant to society in the global context; it is scarce in a community when it depends on its physical availability, the level of human development and technological advancement of the society [1]. Water is a factor of great importance in the development of people, if it becomes scarce in a community, it would threaten its health and well-being, including the quantity, type of service distribution and quality [2].

Many regions in the world are exposed to significant concentrations of manganese (Mn) and arsenic (As) in drinking water, which affects more than 200 million people [3] and has been considered an emerging health problem and a harmful contaminant in drinking water [4].

In Bangladesh, there are reports of these metals present in the water, so shallow and deep wells have been analysed for water with suitable quality parameters (As, Mn and other relevant parameters) in order to find options for potential exploitation sites in the aquifer [5].

In some aquifers in southern China, high Mn concentrations in shallow aquifers in an urbanised Pearl River delta have been reported to be a cause for concern because of the detrimental effects on human health, highlighting that, being urbanised areas, its origin is difficult to find; however, its spatial distribution in various aquifers and regions was delineated to identify its origins in this region [6].

In the Atlantic and Gulf Coastal Plain in the United States, a study was conducted to understand the factors affecting the presence of lead and manganese in untreated drinking water, finding that elevated Mn concentrations are associated with pH ≤ 7.5 and Dissolved Oxygen < 2 mg/ [7]. Elevated Mn and dissolved organic carbon (DOC) concentrations in groundwater are associated with shallow anoxic water tables and soils enriched in organic carbon, allowing Mn to move down into shallow aquifers [8].

In the Central Nile Delta Aquifer, a drinking water source supplying water to more than 6 million people is reported to have high concentrations of dissolved Mn, where it is noted that the source is likely to be associated with carbonate minerals that disturb municipal supply wells [9].

Likewise, in the Amazonian lowlands, hotspots of geogenic groundwater contamination have been identified, which are attributed to As and Mn, reporting Mn values between <0.01 mg/L and 6.6 mg/L [10]. The reference limit value used for health-related manganese is 0.4 mg/l, however, the threshold of acceptability is 0.1 mg/l [11].

Lü, et al., [12] point out that the high concentration of iron (Fe) and Mn in groundwater is harmful to human health, and that the sources of manganese in rapidly urbanising areas are complex.

In Mexico, there has also been a great deal of research on the presence of Mn in aquifers, which have traditionally been used to supply drinking water to society. Romero-Oliva et al [13] state that there is an acceptable toxicological risk of exposure to lead (Pb) and Mn in soils for the inhabitants of urban and peri-urban areas of an irrigation district in Tulancingo Hidalgo; Armendáriz-Hernández [14] also refer to the high levels of Mn concentration in tributaries in the city of Chihuahua.

In the municipality of Guasave, Sinaloa, Mexico, Llanes et al [15] mention the high levels of this metal, which has received very little attention from government bodies. Meanwhile, Ayala-Rodríguez [16] refers that Mn, after Fe, is the most abundant metal in the Sinaloa River.

Given the complexity of the presence of Mg in drinking water and the damage to distribution systems, there is a need for zonal investigations of manganese concentration distributions in groundwater in order to generate maps to determine manganese concentrations in aquifers, thus allowing regional patterns to be identified [17].

The present research work aims to describe the population's perception of the presence of manganese in the municipality of Guasave and to report on the effects of this metal contained in drinking water on the water distribution network, clothing, household utensils, concrete, etc.

2. Methodology

This research addresses the opinion of the social sector of the municipality of Guasave on the perception of the effects of Mn contained in the water used for their domestic activities. To achieve this objective, a survey was applied in the city and the most relevant communities of the municipality of Guasave. The surveys were randomly applied to citizens, ensuring that they were over 18 years of age. From the 2020 nominal list provided by the State Electoral Council, the sample size and the proportion of surveys applied in the city and its main communities was determined.

For the design of the instrument, age, level of education, effects and damages caused by the presence of Mn in the use of water for household consumption were considered. The survey was carried out in person, visiting them in their homes. Subsequently, the information was processed and the graphs corresponding to the items were determined.

This research is based on a non-experimental study, with an exploratory-descriptive, cross-sectional, cross-sectional scope for data collection [18].

For the determination of the sample size, the procedure indicated by Torres et al. [19] was applied in accordance with the following formula:

$$n = \frac{NZ^2 pq}{d^2(N-1) + Z^2 pq}$$

Where,

N = population size 216,779 according to the Nominal List of the municipality of Guasave for the 2020 electoral process in the municipality of Guasave; Z = 95 % confidence level (1.96); p = probability of success or expected proportion (50 %); q = probability of failure (50 %) and d = precision (4.5 % maximum admissible error in terms of proportion).

Substituting the data in the expression, the sample size is

$$n = \frac{216779(1.96)^2(0.5)(0.5)}{0.045^2(204162) + 1.96^2(0.5)(0.5)} = 473.2 \approx 474\ surveys$$

2.1. Study area

Figure 1 shows the study area located in the city of Guasave, Sinaloa, Mexico, where a very warm and hot dry climate predominates, vertisols soils, mean annual temperature of 24.8 °C for the 1986-2015 series, with a precipitation of 875.6 mm for the 1986-2016 series [20].

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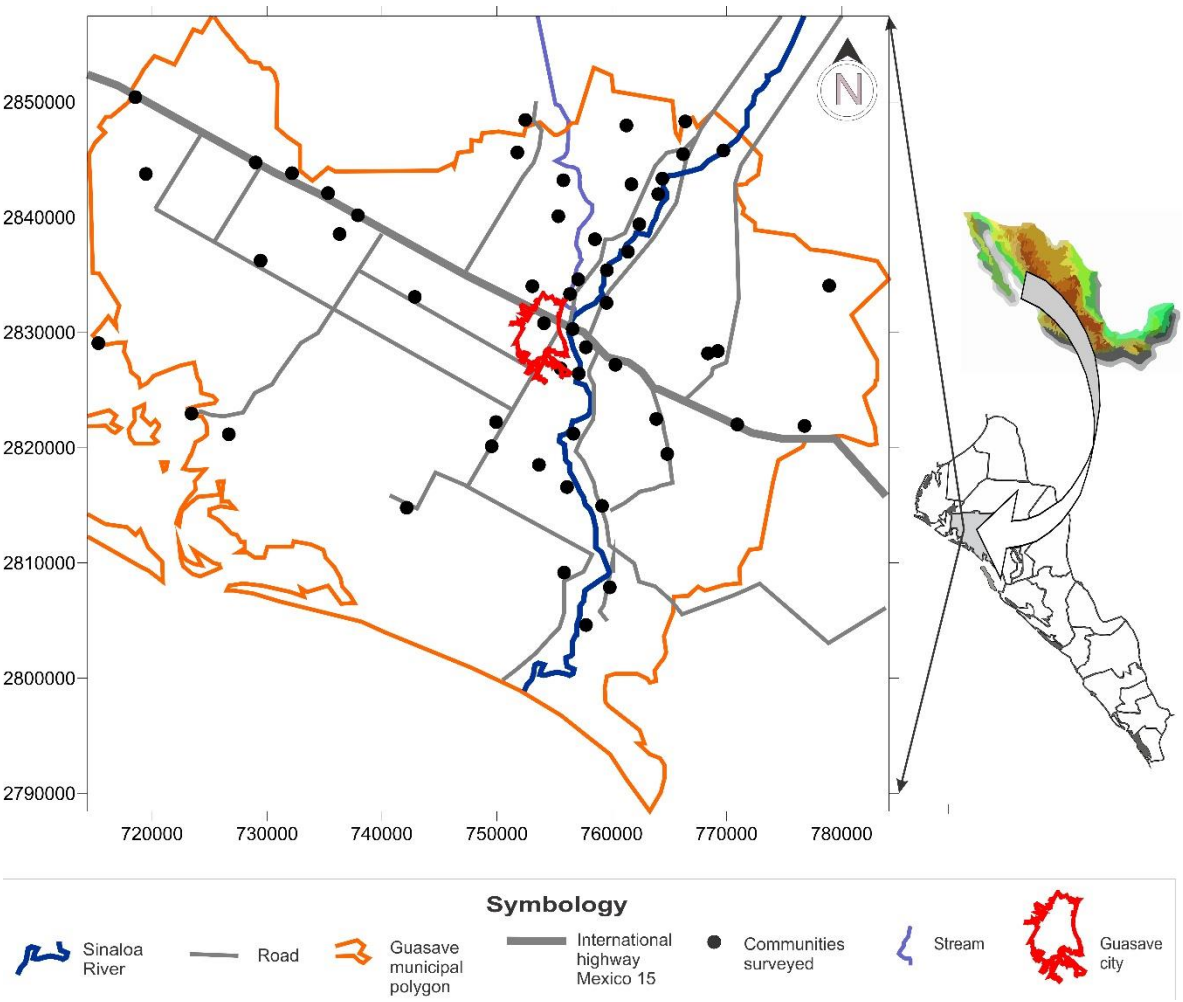

Figure 1. Study area

3. Results and discussion

Characterising the population that was the object of the study, the surveys were applied, of which 70.46% were women and 29.54% men, emphasising that these results were obtained because the instruments were applied directly in the households (see figure 2).

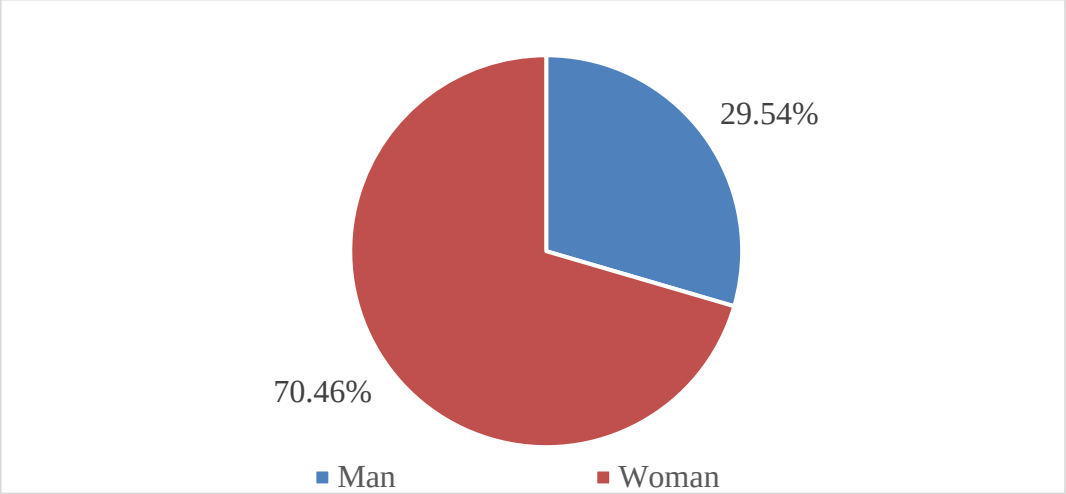

Figure 2. Percentage distribution according to sex of respondents.

Regarding the level of studies of the population studied, it was identified that 18.99 % of the respondents have professional or postgraduate studies, highlighting that 51.27 % have basic education (primary or secondary) and 4.22 % of the population have no studies (see figure 3).

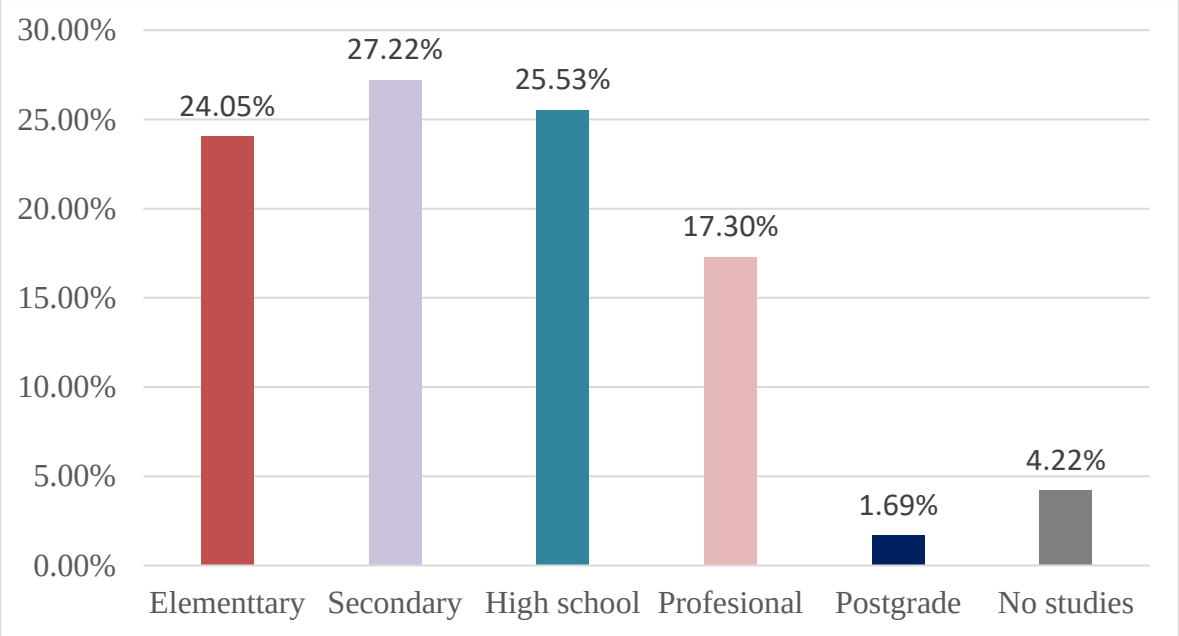

Figure 3. Educational attainment of respondents

The media have repeated on different occasions that, in the municipality of Guasave, there are communities with high concentrations of Mn. For this reason, citizens were asked if they have heard that well water contains high concentrations of this metal in some places in the municipality of Guasave, and 48.31 % of them answered yes (see figure 4).

Despite the fact that the problem is present in most of the municipality, there is a lack of knowledge on the subject, attributing the effects of Mn in their properties to other factors, including salinity.

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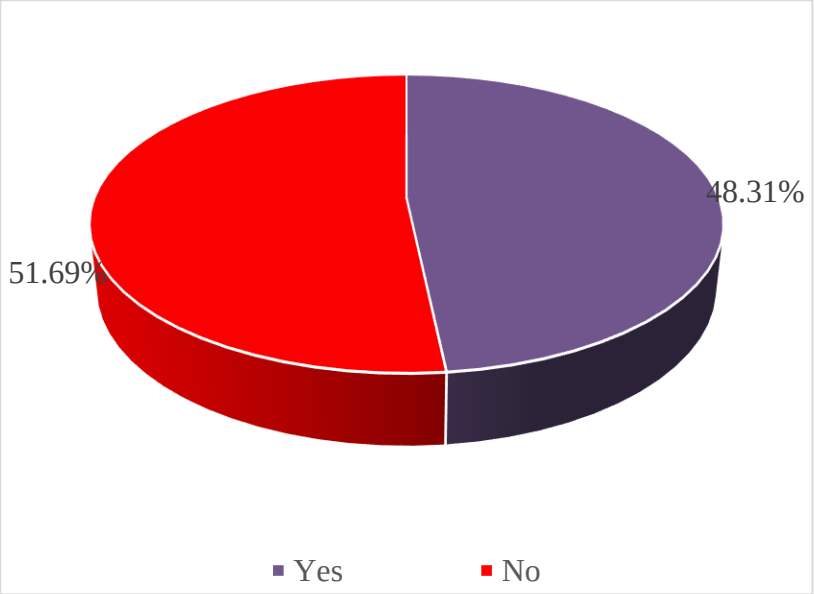

Figure 4. People who have heard that the municipality of Guasave has problems due to the presence of manganese in groundwater.

As a complement to the instrument, those who said they were aware of the issue and are directly affected by Mn contamination in the drinking water services they receive reported some damage; as shown in figure 5, the effects of the water on a basin, which was obtained during the visit to the different communities in the municipality, can be observed. These stains are mainly associated with the presence of the metal.

It is important to note that these effects do not necessarily occur throughout the municipality, as the water used for domestic activities comes from wells; therefore, it is possible that concentrations vary and, therefore, so do the effects. DeSimone and Ransom [4] point out that the aquifer can be subject to different processes and factors that can cause variations in Mn concentrations.

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Figure 5. Some effects of domestic water in the household.

For this reason, they were asked about the colour of the stains they have identified on water basins, toilet bowls, clothes, to which 37.55 % answered that they have noticed brown-black stains, while 34.81 % indicated that they have no problems at home and 27.64 % identified stains of other colours (see figure 6).

World Health Organization [11] states that an Mn concentration higher than 0.2 mg/l often forms a layer in pipes, which can be released as a black precipitate.

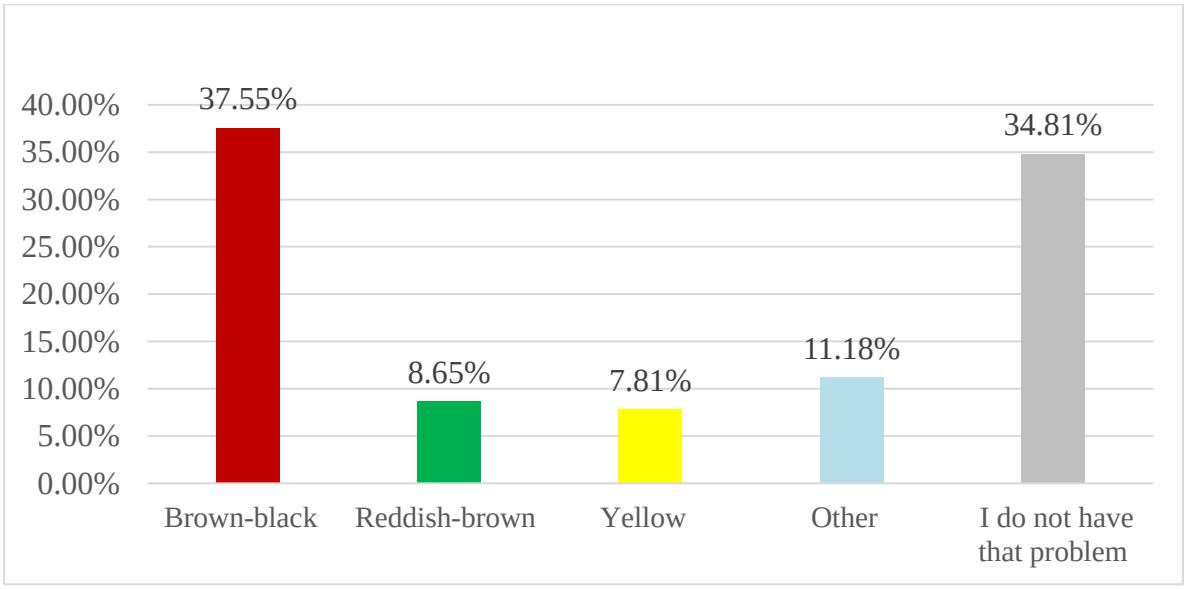

Figure 6. Colour identification of stains detected in the household, mainly on sinks, toilet bowls, clothes.

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In the handling of water in domestic activities, stains may occur in some cases on clothing, porcelain, dishes, utensils, glasses, dishwashers, plumbing fixtures and concrete [21, 22], which are reddish-brown if caused by iron and brownish-black if due to manganese.

When respondents were questioned about problems encountered in different places within the household due to the use of water for their domestic activities, the presence of stains was recorded, mainly on the toilet bowl (55.1 %), basin where water is stored (43.2 %), clothes (39 %), which can be seen in more detail in Figure 7.

It is important to note that Mn concentrations above 0.1 mg/l in water supply systems can produce an undesirable taste in beverages, stain laundry and sanitary devices, and can cause accumulations in tanks in the distribution system [11, 23]. Concentrations of less than 0.1 mg/l are generally acceptable to consumers.

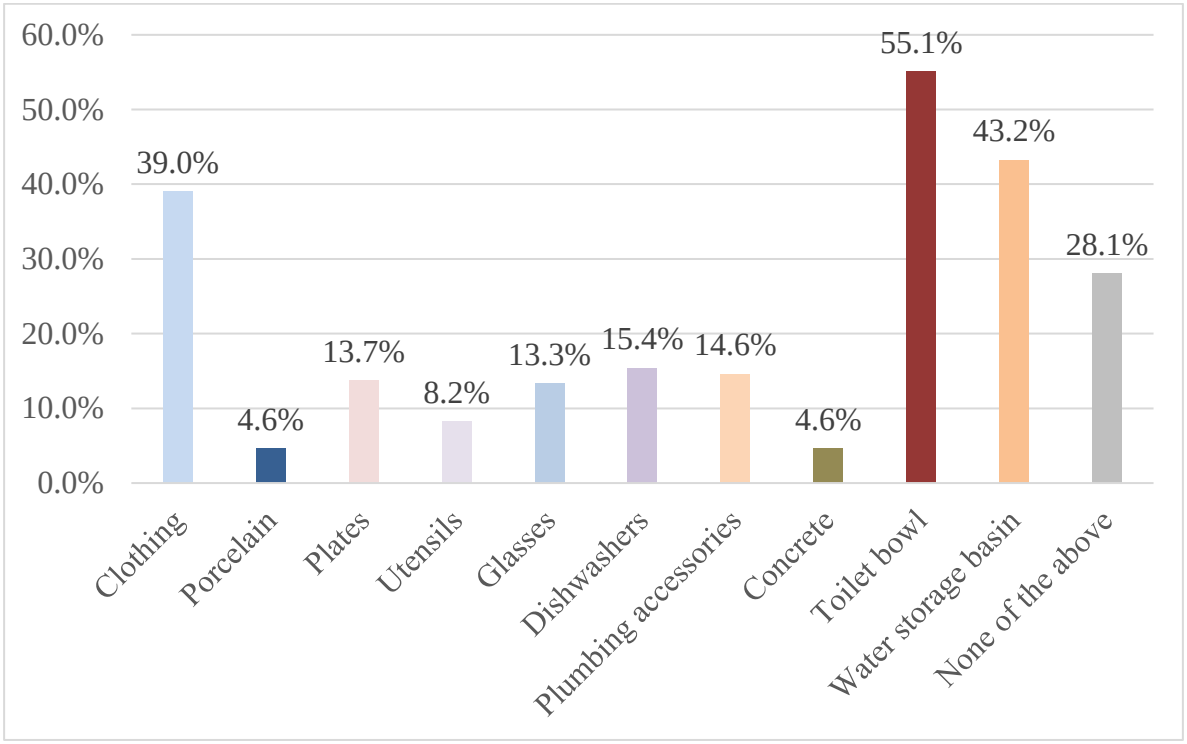

Figure 7. Presence of stains at home related to water use.

Respondents have also indicated that they have noticed clogging and damage to electric showers (51.05 %), water pipes (37.13 %), water tanks (19.62 %), sink faucets, sinks and gardening with 16.46 % (see figure 8).

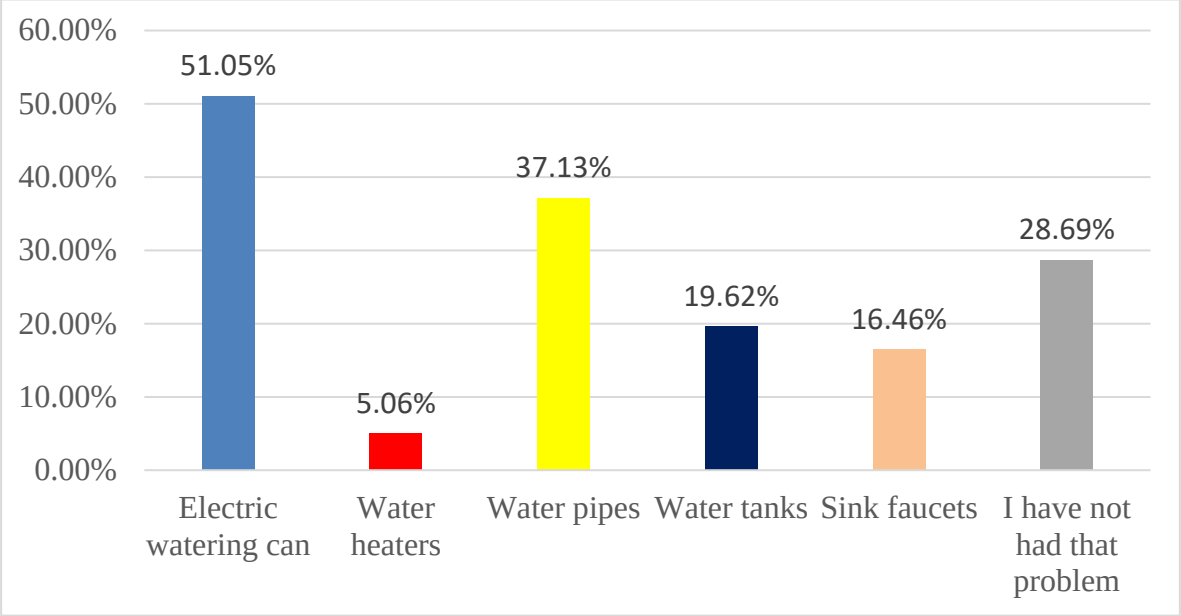

Figure 8. Presence of obstructions and/or damage to the home

The water supplied by the municipal government in the colonies and communities comes mainly from the subsoil through wells, which has different concentrations of salts, which has caused it to be used practically for domestic activities. In the case of drinking water, 99.79 % of citizens indicated that they prefer purified water supplied by purification plants (see figure 9).

In the municipality of Guasave, water comes from wells, varying the concentration of salts and with reports of the presence of Mn, have caused the population to want quality water for human consumption. Knierim et al., [17] state that high concentrations of Mn and As in drinking water represent a risk to human health. In the same sense, Pillajo Kashijint & Ventimilla Celi [24], mention that most of the water supplying the world has the presence of these metals.

Fe and Mn are common in groundwater and when concentrations exceed the limits imposed by legislation, they can cause aesthetic, operational and public health problems [25].

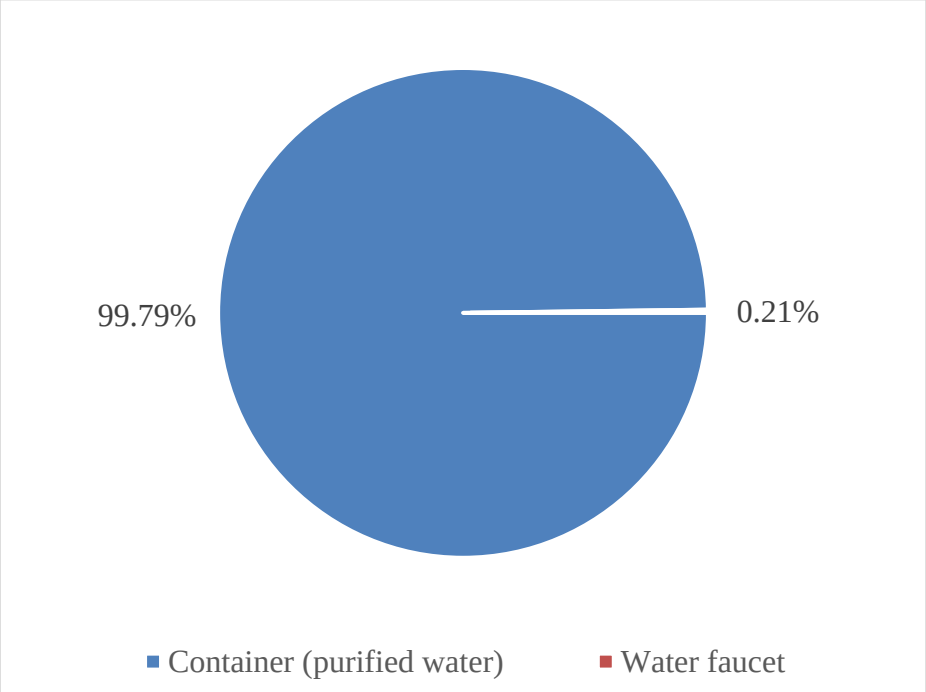

Figure 9. Source of water used for drinking water

Water for public supply with the presence of Fe and Mn generates problems related to maintenance to keep them at quality levels, mainly because the oxidation levels of the salubrious states generate precipitates that give bad taste to the water, as well as giving it colour and can cause obstructions in pipes [26].

Figure 10 shows that citizens have not noticed any strange taste in the water (70.25 %), however, cases have been identified where they have noticed a bitter taste (15.40 %) and 3.59 % sweet.

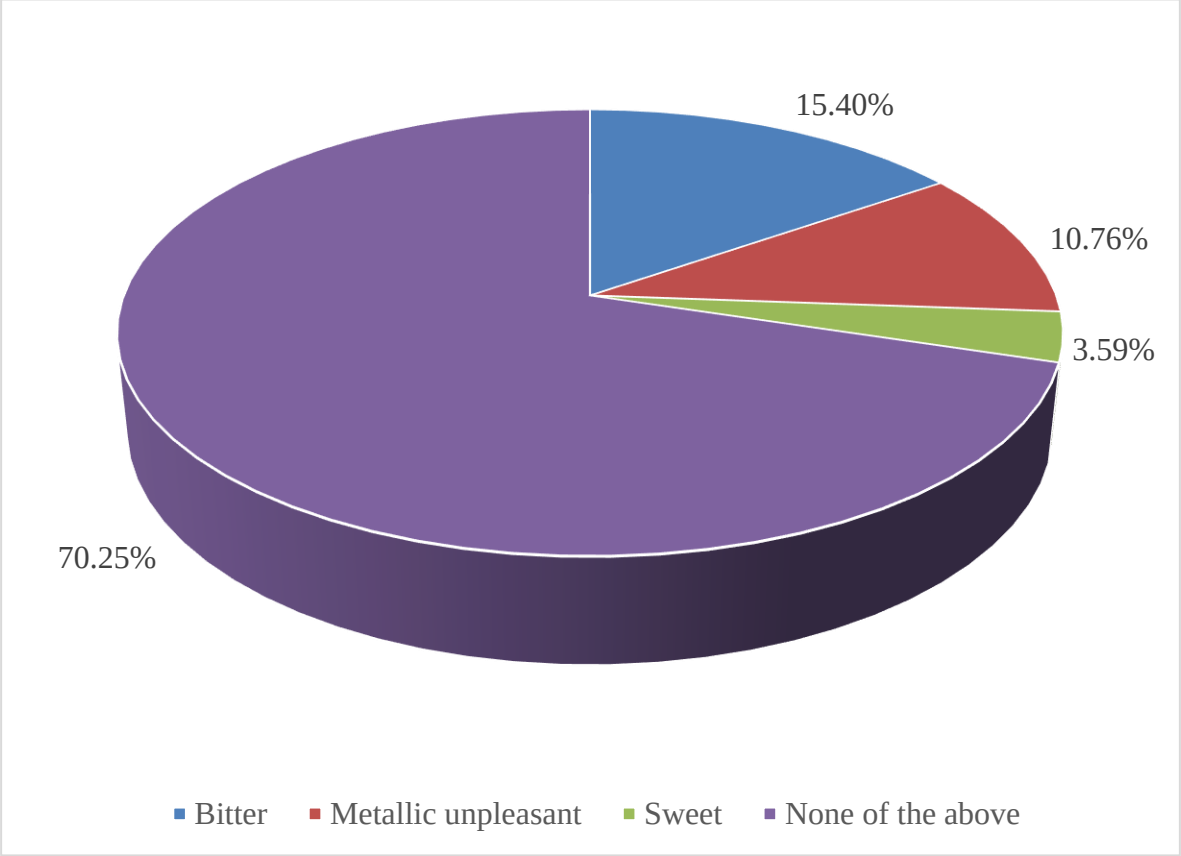

Figure 10. Taste detection in water used for domestic activities.

4. Conclusions

Access to quality drinking water is a fundamental need of humanity, it is a basic right for people. Lacking this water resource is a condition of an economically poor society.

The supply of groundwater for human consumption has become an alternative to meet the demands of society, however, the presence of different metals has been detected, as in this research is the Mn, which, at high levels, represents a health problem for those who consume it.

51.69 % of the population is aware of the presence of Mn in the water supplied by the municipal government through its distribution networks as it comes from wells.

71.9 % of the surveyed population have noticed stains in the household related to water use. Likewise, 71.31 % have noticed damage to the water distribution pipes due to obstructions and/or damages at home.

29.5 % of the citizens consulted indicated that they have detected flavours in the water used for domestic activities. This situation has led society to prefer drinking water from jugs, which affects the local economy, especially the most economically vulnerable population.

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