"Don't Drink The Water": Understanding Water Quality And Availability in Mexico City

Sophia L. Ramirez

ABSTRACT

The scientific evaluation of contaminants and water quality characteristics is essential to protect the lives of people around the world. This study evaluates water quality and health risks in the Mexico City area. We evaluated sixteen water parameters and arsenic in eleven sites varying from tourist attraction areas in Mexico City to rural socially-environmentally variable cities around Mexico City. We assessed water quality using a two-sample t-test to evaluate if there is a significant difference in water quality between rural and tourist sites. The findings demonstrate that lead, sulfate, hydrogen sulfide, and nitrate showed significant levels of these contaminants in rural areas that exceeded EPA standards in comparison to tourist area communities. This study provided awareness for the necessary steps to improve water quality in rural communities in Mexico.

INTRODUCTION

Reliable access to clean water is vital for public health and human development. Groundwater has become a reliable source for supplying drinking water and agricultural irrigation in Mexico. An estimated 38.7 % of drinking water in Mexico is provided through groundwater (CONAGUA 2019). Although groundwater is a valuable source of water in countries like Mexico, groundwater pollution is a health concern. Generally, it is common for pollutants to be added to the groundwater system through human or natural processes. Heavy metals contamination are most often found in groundwater affecting countries that depend on this system for consumption (Alarcón-Herrera 2019).

Groundwater represents Mexico City's primary supply of water, however, the water quality is continuously deteriorating. The consumption of polluted groundwater in Mexico City has raised various concerns such as the toxicity of heavy metals. Studies have found that a major heavy metal contributor to the groundwater system is Arsenic (Alarcón-Herrera 2019) (Mazari-Hiriart 2019). The objective of this research is to analyze and identify the possible contaminants in the water and evaluate the health risks.

The public health risks of water contaminants in the groundwater in Mexico City makes it critical to better understand water quality within the areas. Arsenic is commonly found in groundwater as it is naturally present and lead is more prominent in rural areas due to corroding pipes not being well maintained. The long term health effects of these heavy metals lead to cancer and cardiovascular diseases (EPA 2022). Furthermore, lead and arsenic can be distributed to various regions of the body such as the brain and bones, where it accumulates over time (Engwa 2019). Ultimately, the lack of access to clean usable water drives the population to resort to dangerously arsenic water for life usage, which leads to severe long term side effects (Hong 2014).

The central study of this research will focus on comparing drinking water quality between tourist attractions and rural areas in Mexico City. To narrow down the central idea, a series of questions to navigate this study will include the types of heavy metal contamination that exist in various public water fountains in Mexico City, at tourist and rural sites. Furthermore, we will investigate the significant difference in heavy metal contamination between tourist sites and rural sites. To ensure the study is a community based participatory research, community members of these test sites will be asked for their local knowledge about drinking water contamination. Therefore, the novelty of this study is that this is the first study to focus on 17 parameters of water in tourist attraction areas in Mexico City and rural socially-environmentally variable communities in neighboring cities.

EXTENDED INTRODUCTION

Mexico's Water

To further understand Mexico's groundwater system, a complex analysis of various mediums and transportation methods of water is vital. There are 653 aquifers in Mexico and 115 are overexploited. Comarca Lagunera is one of Mexico's most important agricultural and dairy-product producing districts. The water table has dropped up to 200 meters and produced multiple depression cones as a result of the heavy exploitation of groundwater resources for irrigation during the last century, increasing the energy consumption required to raise and distribute groundwater in agricultural land (Dorjderem 2020). Not only are groundwater flow dynamics continually altering as a result of this long-term overdraft pumping, but water quality has also degraded dramatically in recent decades. In 80% of the sampled sites, arsenic concentrations surpass international drinking water standards, with highest amounts of up to 349 µg/l in agricultural fields ((Dorjderem 2020). Therefore, various Arsenic tests in Mexico City will be conducted through public drinking water samples to see the levels of arsenic between different areas in Mexico City and compare it to the national average.

Water bottle culture

Although water is available throughout Mexico, the groundwater contamination leads Mexico's population to resort to other mediums such as bottled water and Coca-Cola consumption (COHA 2018). In other words, local individuals are informed and knowledgeable about the risks to their social determinants of health which drives them and makes individuals more inclined to resort to plastic water bottles. Due to the community's knowledge that water in Mexico City is contaminated, individuals buy water bottles due to lack of confidence in water quality (Trinidad Ramirez, pers. comm.). Moreover, popular worries about the likelihood of microbiological and chemical pollutants in tap water, consumption of purified bottled water in Mexico has consistently increased. In recent years, the percentage of families purchasing bottled water has climbed by ten percentage points annually worldwide (Hu 2011).

Arsenic and lead maintenance

High levels of arsenic and lead are predominantly found in socio-environmentally vulnerable communities due to decline in water and erosion regulating ecosystem services that are available. For example, maintenance and regulations in ecosystem services is more primarily seen in residential areas in comparison to socio environmental vulnerable communities leading to higher levels of clean water quality in residential areas. The study, *Mapping socio-environmentally vulnerable populations access and exposure to ecosystem services at the U.S.–Mexico borderlands* concluded that socio environmentally vulnerable communities are subjected to a decline in water and erosion regulating ecosystem services (Norman 2012) . A modified Socio-Environmental Vulnerability Index was used to generate an index ranging between 0 and 1, representing low to high socio-environmental vulnerability in relation to erosion in soil and water. The residential area of Heroica Nogales, Sonora demonstrated low socio environmental vulnerability of 0.11 per Modified Socio-Environmental Vulnerability Index range. In socio-environmental vulnerable areas in Sonora, Mexico, the communities of Solidaridad, Flores Magon, and Margarita Maza de Juarez reported a decrease in both erosion prevention and flood control services, therefore resulting in 0.37-0.39 per Modified Socio-Environmental Vulnerability Index range (Norman 2012).

Effects of government standards for rural communities

Mexico's government has regulation and oversight of tourist area communities throughout the country. As a result, there is a lack of regulations and standards in rural communities that are at a higher risk of lead contamination. Therefore, this research will consist of water samples from community members tap water to test whether lead is more prominent in rural or urban areas.

METHODS

Study sites

To establish the collection sites, I focused on rural socio-environmentally vulnerable communities and compared them to tourist attraction areas/communities in Mexico City. The study sites used for the low-income proportion of the study include: Milpa Alta, Iztapalapa, Tláhuac, and Xochimilco. For tourist attractions, Mexico City D.F., Chapultepec, and Zócalo are used as they are one of the most visited areas in Mexico City (Figure 1).

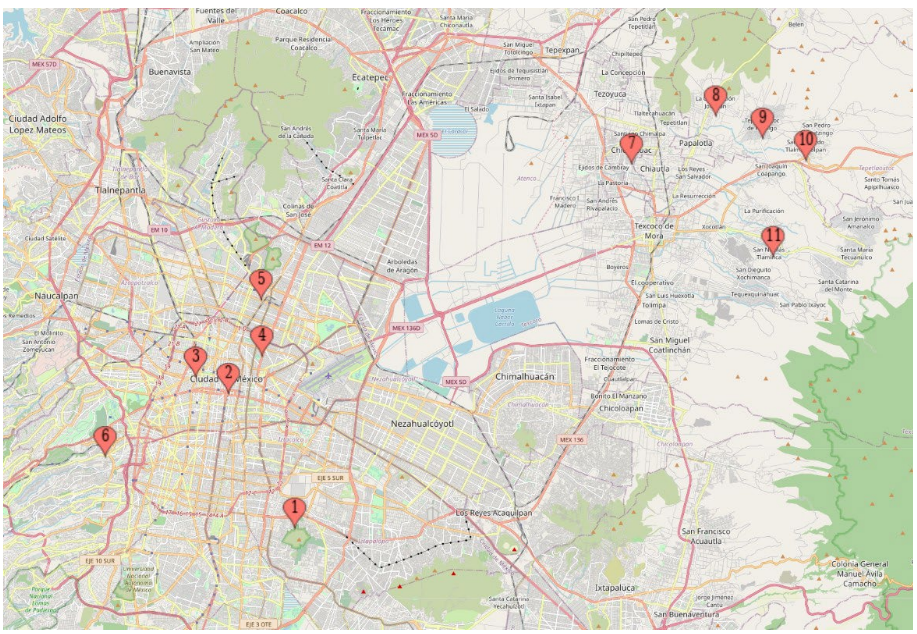

Figure 1. City mapping along with sample collection sites

Water sampling

To observe the contaminants and arsenic levels found within the water collections, I used HACH's Arsenic Low Range Test Kit. The test strips range from 0 to 500 ppb with small increments steps of 0, 10, 30, 50, 70, 300 , 500 ppb which allow for precise data to be found in water samples. Through the small increment steps I was able to find an exact measure of how distinct collection sites were. Another vital field equipment used for this research is Variety's 17 in 1 Premium Drinking Water Test Kit that tests for 16 water parameters that includes lead, iron, copper, nitrate, nitrite, fluoride, mercury, zinc, pH, sulfate, hardness, total alkalinity, manganese, total chlorine, hydrogen sulfide, and sodium chloride. Lead and copper allowed me to determine whether or not water pipes play a role in the detection of heavy metals.

Analysis

A bar graph is used to visually show the detected levels of the 16 water parameters from the collected data. The x-axis is labeled as the exact number of the element found at the site and the y-axis is labeled as the site's name. To conclude whether or not socio-environmentally vulnerable communities have higher levels of contaminants and arsenic in their water in comparison to urbanized tourist sites, a two tailed t-test is used. If the p-value is less than 0.05 then we reject the null hypothesis that there is no significant correlation between rural and urban having a difference in water quality.

Community Engagement

To enact a Community-Based Participatory Research approach, qualitative data was collected through interviews and testing water parameters with community members of the areas of study. Through this process, we were able to fill gaps in understanding the study and improving interpretations of the findings. Therefore, a series of 11 interviews were conducted in all sites of study through a process of steps to ensure consent. A brief description of the study was informed to community members, who were then approached for permission to collect water samples from their taps. After collecting three water samples, I demonstrate to the community members how to interpret the provided test strip after immersing them in water. The individual is then given the opportunity to perform their own test and annotate their findings, and finally, we complete one jointly to compare results. Following the procedures, the interviewee was asked a series of questions ranging from vague to more detailed ones in order to develop deeper level thinking and be in a water quality mindset.The interviews consisted of the following questions: (1) What does water mean to you? (2) In which ways do you utilize the tap water from home ? (3) What have you noticed about the smell, taste, or appearance of your tap water? (4) What have you heard about drinking tap water? (5) What do you know about the drinking water quality? . These interviews were conducted to understand whether or not water quality is an issue seen among many and if there is a common knowledge of the water quality.

RESULTS

Water parameters assessment

This study assessed the water quality and health concerns of sixteen water parameters and arsenic levels in eleven locations ranging from tourist attractions in Mexico City to rural cities neighboring Mexico City. Four out of the sixteen water parameters tested were significantly above EPA standards leading to health risks in rural areas. Rural areas contained significantly higher levels of lead, sulfate, hydrogen sulfide, and nitrate in indicating that there is a lack of regulations and standards in rural communities. San Miguel Tlaixpan, San Bernardo, Tepetlaotoc, Jolalpan, and Chinconcua had higher levels of lead than the EPA recommended levels of 0 -15 ppb (EPA), as the average concentrations of these sites were 33.4 ppb (Figure 2). Sulfate concentrations in rural areas averaged 740 ppm (Figure 3), over 3 times the EPA standard of 0 - 200ppm. Hydrogen sulfide standards were not met as the average of 0.46 ppm (Figure 4) was found in rural areas in comparison to the EPA standard of 0ppm. Nitrate averaged 12ppm (Figure 5) which was slightly over EPA standard of 0-10ppm. In contrast, in the tourist attraction communities of Colonia Hidalgo, Delegación Gustavo Madero, Felipe Angeles, Delegación Cuauhtémoc, Zocalo, and Delegacion Ixtapalapa, the average lead concentration was 25.167 ppb (Figure 2), which although higher than EPA recommended, it contained lower concentrations of lead than rural sites. Sulfate averaged 200 ppm (Figure 3) , around the EPA standard, 0.3 ppm concentration of hydrogen sulfide was found (Figure 4), and nitrate averaged 8ppm (Figure 5).

Two tailed t-tests conducted on the four water parameters of lead, sulfate, hydrogen sulfide, and nitrate were all below the p-value of 0.05. The p-value of lead is 0.01363527, sulfate is 0.00067376, hydrogen sulfide is 0.006989965, and nitrate is 0.009020468 (Table 1). Based on the values, we reject the null hypothesis, there is a significant difference between socially-environmentally variable cities and those of tourist attraction urban areas.

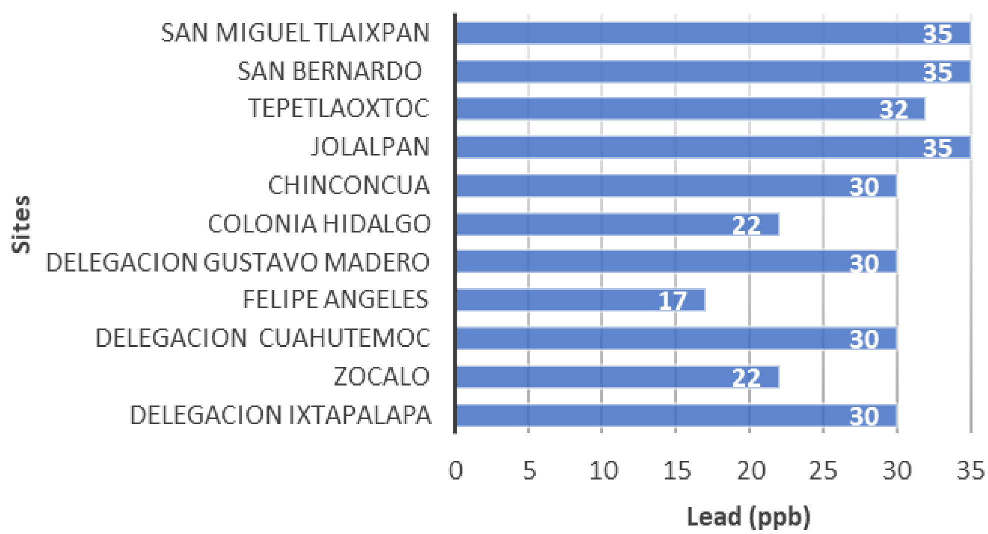

Figure 2. Lead Assessment.

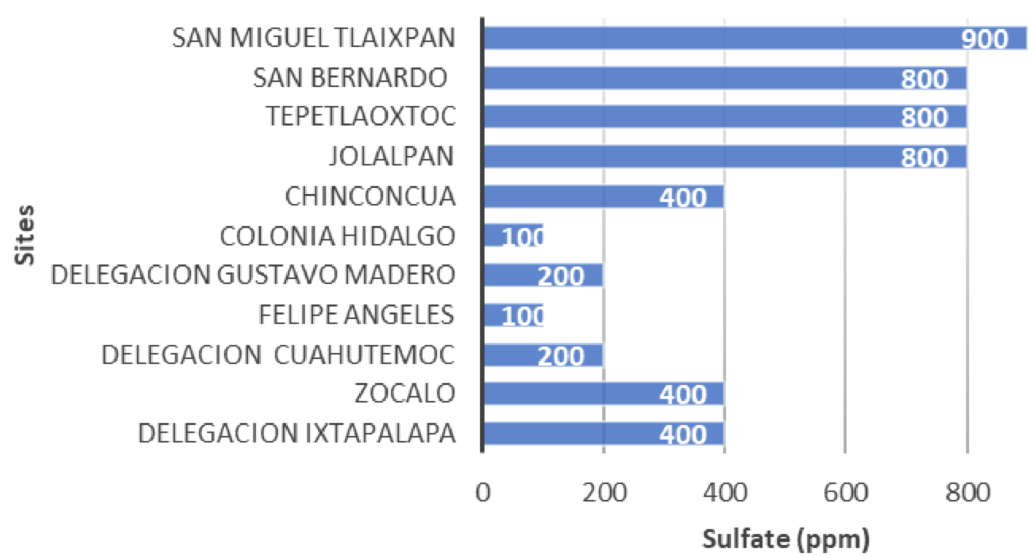

Figure 3.Sulfate Assessment.

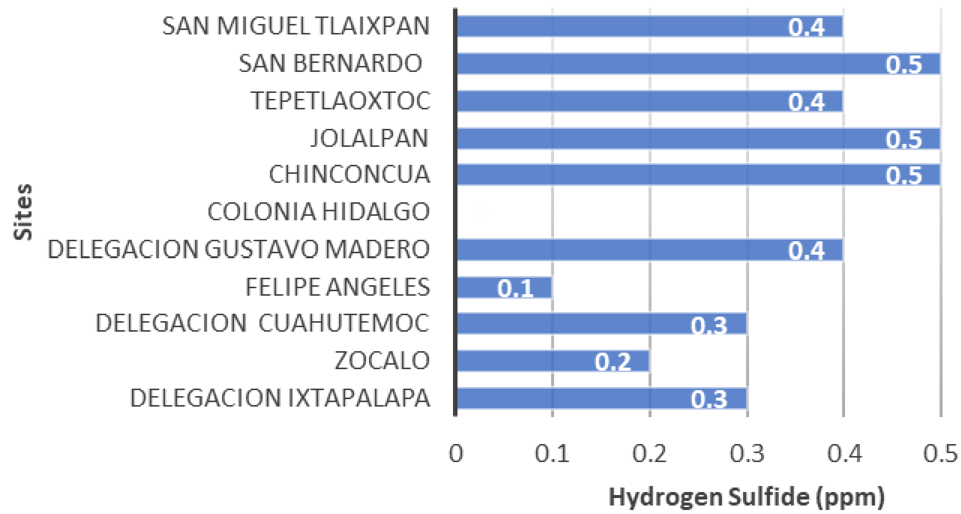

Figure 4. Hydrogen Sulfide Assessment.

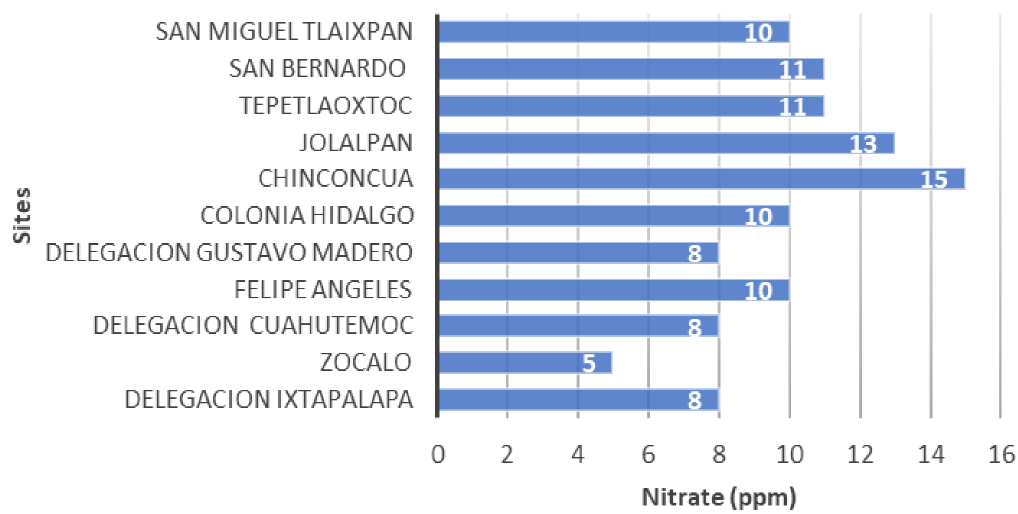

Figure 5. Nitrate Assessment.

Table 1. Summary of p-values used in the study.

Water Parameter	T-test p-value
Lead	0.01363527
Sulfate	0.00067376
Hydrogen Sulfide	0.006989965
Nitrate	0.009020468

Arsenic

Based on the HACH's Arsenic Low Range Test Kit, there was not a detection of arsenic levels found in rural areas or urbanized tourist sites. Therefore, I can conclude that arsenic is not a level of concern in Mexico City or the neighboring sites. I was astonished that there was no detection of water considering groundwater supplies an estimated 38.7 percent of Mexico's drinking water, and arsenic is a key heavy metal contributor to the groundwater system (CONAGUA 2019).

Community knowledge

To address the need for improved water quality and regulations, community members of the eleven sites were asked a series of questions to identify the knowledge gap between consumed water and the found contaminants. Every individual from the interview stated that water is a vital source that is utilized in everyday life even though there is a common knowledge that the water is contaminated. Common statement among many is that there is controversy on whether or not to use tap water, there are rumors saying not to drink water. The reason for not this rumor is that at times, individuals have had an experience with water smelling sour, similar to the smell of rotten eggs which is caused by sulfide hydrogen.

DISCUSSION

Analysis of Water Parameters

My results show that lead levels averaged 33.4 ppb in rural areas, which were significantly higher than both the EPA standard and sulfate levels in tourist attraction urban communities. High levels of sulfate in groundwater sources have been identified in other studies. One study *Assessment of Drinking Water Sources for Water Quality, Human Health Risks, and Pollution Sources: A Case Study of the District Bajaur, Pakistan* was conducted to assess the quality of different drinking water sources and impacts of poor water quality on human health in the district of Bajaur, Pakistan. Through questionnaire surveys and drinking water samples collected, it was found that total suspended solids and bacteriological contamination exceeded the drinkable limits of the WHO in all of the water sources. The major finding of the research is that lead was above the WHO standards in some samples. In terms of my own research, this study mirrors my own findings, as the element of lead significantly affected water quality. Given these results, it makes sense to study as lead pipes deterioration will have a significant effect on water quality. High levels of lead cause anemia, weakness, and kidney and brain damage, and can disrupt a fetus's nervous system (Centers for Disease Control and Prevention).

According to my findings, sulfate levels in rural regions averaged 740 ppm, which was much higher than both the EPA limit and sulfate levels in urban areas. This result also aligned with statements from interviewees, who mentioned that there was an odor when drinking their water resulting from exceeding hydrogen sulfide levels caused by the significantly high sulfate levels. High sulfate levels can cause serious health concerns, like reducing lung function, aggravated asthmatic symptoms, and at times death in individuals who have chronic heart or lung diseases (California Air Resources Board).

My findings demonstrate that hydrogen sulfide levels in rural regions averaged 0.46 ppm, which was much higher than both the EPA limit and sulfate levels in rural areas. This conclusion was indeed consistent with remarks made by interviewees, who reported a rotten egg odor that is directly related to hydrogen sulfide levels. Sulfate is a problem in other regions of the world as well. Research in rural areas in the Tiruchirappalli region of Tamil Nadu, India, discovered significant amounts of hydrogen sulfide as the overall water quality was poor. High quantities of hydrogen sulfide can cause major health problems, such as respiratory discomfort (Center for Disease Control and Prevention).

My findings demonstrate that nitrate levels in rural regions averaged 12ppm, which was much higher than both the EPA limit and sulfate levels in remote areas. High sulfate levels can cause major health consequences, including increased heart rate, nausea, and stomach cancer (Minnesota Department of Health).

My results show that arsenic levels were not present in rural socially-environmentally vulnerable cities or urbanized tourist communities. High levels of arsenic in groundwater sources in Mexico have been identified in other studies. Sulfate is also an issue seen in many parts of the world. One study analyzed the depth of tubewell and the associated concentration of arsenic in drinking water within the arsenic-affected regions in Bihar, India. Through a survey of 935 tubewell from two arsenic contaminated blocks in Bihar and water samples it was found that As concentration is predominantly found in shallow tubewells. The major finding of the research is that households were not aware of the As in drinking water as surveys revealed that 48% of the respondents were aware of iron in the drinking water and only 28.5% were aware of the As in drinking water (Thakur 2021). This is different from my study because I was unable to detect a presence of arsenic in the water samples. High levels of sulfate can cause serious health concerns, like sore throats, irritated lungs, bowel discomfort, and at times fatal (American Cancer Society).

Limitations

This research highlights the need for community members to be well-informed of the water contaminants to prevent water quality deterioration and factors that may be hindering human health. For future direction, Brita water pitcher filters will be provided to community members of the eleven sites. Furthermore, summer of 2022, community members will be informed and updated of the water quality and the contaminants found.

CONCLUSION

This study investigated sixteen water parameters and arsenic samples from eleven sites varying from tourist attraction areas in Mexico City to rural socially-environmentally variable cities around Mexico City. The results of this study revealed the issue of rural water quality that is prevalent around the world. Water quality is poorer in rural areas compared with that in urban tourist communities specifically in lead, sulfate, hydrogen sulfide, and nitrate concentration in water. This study also emphasized the potential health risks of water contaminants to consumers over long-term consumption such as brain damage, kidney failure, irritation to the respiratory system, gastric cancer etc. The significant factor which poses a considerable threat to the water quality is the deterioration of the lead pipes in rural areas. Water quality may be improved by economical sanitation systems, monitoring efforts, and awareness of maintaining water pipes that are directly utilized for consumption. As a result, it is clear that there is an urgent need to implement the provided procedures to ensure the well being of community members in Mexico City who desperately have a need for change. Everyone needs and deserves access to safe drinking water and sanitation right at home.

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