Water supply infrastructure for human consumption in the Brazilian semiarid region

Infraestrutura de abastecimento de água para consumo humano no semiárido brasileiro

Infraestructura de abastecimiento de agua para consumo humano en la región semiárida brasileña

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ABSTRACT
In Santo Estevão, the public water supply system is operated by the Infrastructure Directorate of the entire Baiana Water and Sanitation Company (EMBASA) and accounts for around 85% of the water supply of the Bahian population. The rest of the population is supplied by cisterns, pipes, or artesian wells. The objective of this research was to identify the regions with the greatest deficiencies in the distribution of water supply in
the urban area of the city of Santo Estevão and the consequences of this problem for the population. The field of study covered three neighborhoods in the city of Santo Estevão (Alto do Porrão, Mutirão, and Pau de Vela). GPS, Cartography, and Geographic Information Systems were used to demarcate points relating to the spatial distribution of water and create thematic maps. Data and information related to water supply were collected in institutions and public bodies, such as the City Hall of Santo Estevão, EMBASA, Superintendency of Statistics and Information, and the Brazilian Institute of Geography and Statistics, in addition to the application of forms. It was found that some residents do not store water in water tanks correctly, which can cause the proliferation of disease vectors, such as the Aedes Aegypti mosquito.

**Keywords:** Water Supplying, Santo Estevão, Infrastructure, Semiarid.

**RESUMO**
Em Santo Estevão o sistema público de abastecimento de água é operado pela Diretoria de Infraestrutura de toda a Empresa Baiana de Águas e Saneamento (EMBASA) e responde por cerca de 85% do abastecimento de água da população baiana. O restante da população é abastecido por cisternas, tubulações ou poços artesianos. O objetivo desta pesquisa foi identificar as regiões com maiores deficiências na distribuição do abastecimento de água na zona urbana da cidade de Santo Estevão e as consequências deste problema para a população. O campo de estudo abrangeu três bairros da cidade de Santo Estevão (Alto do Porrão, Mutirão e Pau de Vela). GPS, Cartografia e Sistemas de Informação Geográfica foram utilizados para demarcar pontos relativos à distribuição espacial da água e criar mapas temáticos. Foram coletados dados e informações relacionados ao abastecimento de água em instituições e órgãos públicos, como Prefeitura de Santo Estevão, EMBASA, Superintendência de Estatística e Informação e Instituto Brasileiro de Geografia e Estatística, além da aplicação de formulários. Verificou-se que alguns moradores não armazenam água em caixas d’água corretamente, o que pode provocar a proliferação de vetores de doenças, como o mosquito Aedes Aegypti.

**Palavras-chave:** Abastecimento de Água, Santo Estevão, Infraestrutura, Semiárido.

**RESUMEN**
En Santo Estevão, el sistema público de abastecimiento de agua es operado por la Dirección de Infraestructura de toda la Empresa de Agua y Saneamiento de Baiana (EMBASA) y representa alrededor del 85% del suministro de agua de la población bahiana. El resto de la población se abastece de aljibes, tuberías o pozos artesianos. El objetivo de esta investigación fue identificar las regiones con mayores deficiencias en la distribución del suministro de agua en el área urbana de la ciudad de Santo Estevão y las consecuencias de este problema para la población. El campo de estudio abarcó tres barrios de la ciudad de Santo Estevão (Alto do Porrão, Mutirão y Pau de Vela). Se utilizaron GPS, Cartografía y Sistemas de Información Geográfica para demarcar puntos relacionados con la distribución espacial del agua y crear mapas temáticos. Se recolectaron datos e informaciones relacionadas con el abastecimiento de agua en instituciones y organismos públicos, como la Municipalidad de Santo Estevão,
EMBASA, Superintendencia de Estadística e Información y el Instituto Brasileño de Geografía y Estadística, además de la aplicación de formularios. Se constató que algunos vecinos no almacenan correctamente el agua en los tanques, lo que puede provocar la proliferación de vectores de enfermedades, como el mosquito Aedes Aegypti.

**Palabras clave:** Suministro de Agua, Santo Estevão, Infraestructura, Semiárido.

1 INTRODUCTION

Water is an indispensable element for human survival and society's development. Heller (2006) highlights that the availability of water in nature has been insufficient to meet the demand in many regions of the planet, a phenomenon that has been increasingly worsening. The author further emphasizes that: Water supply facilities must be able to provide quality water regularly and affordably to populations, while also respecting the interests of other users of the water sources utilized, considering both present and future generations (Heller, 2006, p. 29).

According to Padula et al. (2013), in many places, including many cities, the water demand is growing. Given the time it takes to obtain permission, finance, and build water infrastructure, water planners are often tasked with establishing plans well in advance on how they plan to address the future balance between water supply and demand. Thus, planning to ensure a quality water supply for population consumption is necessary. Therefore, providers of potable water have a comprehensive responsibility to supply safe, clean, and healthy drinking water (Lundqvist, et al., 2024).

Funasa (2006, p. 36) highlights, in terms of relevance, the main sanitary and economic conditions of water supply, among which can be cited: controlling and preventing diseases; implementing hygiene habits in the population; promoting public cleanliness; increasing population life expectancy rates; reducing mortality rates; increasing individual productive life, either through increased life expectancy or reduced time lost to illness. For the population to achieve such benefits, the supply of this resource must be provided regularly and with quality.

Considered an abundant resource, water is used in various ways by society.
However, with the growth of human settlements and the consequent increase in water consumption, humans have begun to undertake large-scale projects aimed at human (domestic and industrial) water supply, irrigation, animal watering, energy generation, and transportation, among others. Additionally, there has been an increase in the production of domestic and industrial waste (sewage) that is discharged in its raw form, polluting and contaminating surface and underground water bodies.

In Santo Estevão, as in most municipalities in Bahia, the public water supply system is managed by the Department of Infrastructure through the Bahia Water and Sanitation Company (EMBASA), which serves approximately 85% of the urban population. The remaining portion of the population is supplied by cisterns and dug wells, tubular or artesian wells.

Cisterns are small reservoirs that store rainwater, and this water, when used for domestic purposes, must be boiled or chlorinated beforehand. Another alternative supply form is dug wells, known as shallow or groundwater wells. FUNASA defines dug or shallow wells as with a minimum diameter of 90 centimeters, which are intended for both individual and collective supply (Funasa, 2006, p. 64).

Another type of well known as a deep tubular well captures water from confined or artesian aquifers located beneath the water table, between two impermeable layers. The diameter ranges from around 150 to 200 mm, and the depth varies from 60 to 300 meters or more, depending on the location of the aquifer.

The area for the development of this work refers to the urban area of Santo Estevão (Figure 1), a municipality located in the state of Bahia. Santo Estevão has a total area of 366.597 square kilometers, with a total population of 47,880 inhabitants, according to the 2012 census. It is located on the banks of BR 116, in the microregion of Feira de Santana, in the Paraguaçu Valley. It is bordered by the municipalities of Ipecaetá, Rafael Jambeiro, Antônio Cardoso, Castro Alves, and Cabaceiras do Paraguaçu.
The spatial focus chosen relates to three areas within the urban perimeter of the municipality: Alto do Porrão, Mutirão, and Pau de Vela. In these areas, serious problems related to sanitation, particularly concerning water supply, pose a significant threat to the environment and consequently to public health. Thus, the main objective of the study was to identify the areas with the greatest deficiencies in water supply distribution in the urban area of Santo Estevão municipality and their consequences for the population.

2 METHODOLOGY

For the development of this study, an exhaustive literature review was initially conducted on the studied phenomenon, along with the collection of data and information from public institutions and organizations, including the Municipal Government of Santo Estevão, the Bahia Water and Sanitation Company (EMBASA), the Superintendence of Statistics and Information (SEI), and the Brazilian Institute of Geography and Statistics (IBGE).

Subsequently, the use of geoprocessing techniques through Global Positioning System (GPS), Cartography, and Geographic Information System (GIS) was initiated to mark points related to water distribution. The aim was to identify areas with a higher frequency of diseases that may be caused by the absence or inadequate distribution of
water, for the subsequent preparation of tables and thematic maps.

The methodological procedure employed constitutes what is known as a case study, which is most suitable for investigating the studied phenomenon. As this is a case study, the population selected for analysis in its entirety was the urban population, so the spatial delineation will consider the territorial boundaries of its division into areas, directly linked to the dynamics of the studied phenomenon. It is worth noting that this spatial delineation reflects not only the socio-economic and environmental conditions of the population but also its quality of life. The selected areas were Alto do Porrão, Mutirão, and Pau de Vela (Figure 2), which are considered peripheral and low-income areas, each with its particularities.

Figure 2 - Map of Study Areas Location: Mutirão, Alto do Porrão, and Pau de Vela


2.1 DATA COLLECTION INSTRUMENT AND TECHNIQUE

To identify elements and information regarding the water supply issue in the municipality, forms with closed-ended questions were used. The form is a tool characterized by direct contact between the researcher and the informant. The difference between a questionnaire and a form is that the questionnaire is filled out by the respondents themselves, whereas the form is filled out by the researcher. One of the advantages of using a
form is that the informant can discuss with the researcher, potentially reformulate the proposal, clarify some questions, and provide explanations, in other words, adjust the form to the experience and understanding of each informant. The form presents an advantage in that the informant does not need to know how to read and write, and a disadvantage is that they cannot verify what was written by the researcher (SANTANA, 2010).

The form was used to request data and understand the local population’s perception of water supply. The sample size represents the total number of forms applied in inhabited houses within the study area (Table 1).

<table>
<thead>
<tr>
<th>Town</th>
<th>Neighborhood</th>
<th>Number of Residences</th>
<th>Number of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santo Estevão</td>
<td>Alto do Porrão</td>
<td>568</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Mutirão</td>
<td>400</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Pau de Vela</td>
<td>469</td>
<td>47</td>
</tr>
</tbody>
</table>

Source: Compiled by the authors, 2013

Thus, in the application of the questionnaires, households were alternately selected through a lottery draw of house numbers. According to some authors, for a sample to be representative, depending on its size, it should cover a fixed percentage of the population, approximately 10% to 20%. Therefore, 144 questionnaires were administered in the three areas studied, which represents 10% of the households selected to participate in the research.

2.2 DATA ANALYSIS AND SPATIALIZATION

The data obtained through the questionnaire were organized and tabulated. Subsequently, a basic statistical analysis was conducted to obtain the mean and percentage of households that are served or not served by water supply after statistical analysis of the data, graphs, and tables were generated to facilitate visualization of the tabulated information.
To find the percentage of the data, a simple three-rule proportion was applied; however, there is another way to find the percentage results, which is through simple arithmetic mean. According to Crespo (2009, p. 187), the arithmetic mean is the quotient of dividing the sum of the variable's values by the number of values.

With the results obtained from the simple three-rule proportion, tables, and graphs for the study were generated. For the creation of maps, technical field visits were conducted to georeference the spatial coordinates of the study areas. Additionally, the municipality’s Department of Public Works provided some maps for better visualization of the area; some photographs were taken to assess the water supply conditions of the households in the areas, along with the information collected from the questionnaire surveys. The maps were created using ARC GIS 10 and SPRING 4.3.3 software.

In this study, a point pattern analysis was conducted to estimate the frequency of diseases in the analyzed areas. According to Câmara and Carvalho (2002, p. 03), point pattern analysis ‘is defined as a set of irregularly distributed points on a terrain, whose location was generated by a stochastic mechanism.’ A simple alternative to analyze the behavior of point patterns is to estimate the point intensity of the process across the entire study region (Câmara and Carvalho, 2004). The estimates are calculated through interpolations using various methods such as kriging, trend surface, local regression models, and kernel estimator. When applied to a pattern of point events, these techniques generate a contour map of estimated intensity across the entire study area.

The method used for the research development consisted of the kernel estimator, an interpolator that enables the estimation of event intensity across the entire area, indicating the frequency of diseases in Alto do Porrão, Mutirão, and Pau de Vela, even in regions where the process did not generate actual occurrences. The quartic kernel estimator, which is the model adopted by the SPRING application, obtains an estimate of the intensity of the point pattern.
3 RESULTS AND DISCUSSION

3.1 THE VARIOUS FORMS OF WATER SUPPLY FOR HUMAN CONSUMPTION IN SANTO ESTEVÃO

According to Gusmão (2008), the best way to supply water for consumption without health risks is through a public treatment network, aiming to distribute water in sufficient quantity and quality to the population. However, most of the time, the best solution to address water supply issues is not necessarily the safest, most economical, or even the most modern, but rather the one that is suitable for the social reality in which it will be implemented (Garcia and Goméz, 2022). Unfortunately, in most Brazilian states, the population still struggles with this social issue.

The Bahia Water and Sanitation Company (EMBASA) operates in 361 municipalities in Bahia, through thirteen Regional Units (RUs) located in the interior, and six RUs in the metropolitan region of Salvador, along with their respective Local Offices (LOs). The Pedra do Cavalo Dam, on the Paraguaçu River, is responsible for supplying water to the municipality of Santo Estevão.

The municipality of Santo Estevão, in addition to being supplied by EMBASA, also utilizes other means of water supply. The alternative means of supply found in the study areas were cisterns and dug wells (Figure 3).
When evaluating the water supply of the studied areas, it is observed that all have a water supply percentage by EMBASA of over 80% (Table 2 and Figures 4 and 8). Alto do Porrão receives 100% of its water supply, Mutirão 97%, and Pau de Vela 85% from the Bahia Water and Sanitation Company. Figure 7 also shows the significant diversity of water supply by the population of Pau de Vela compared to the other studied areas, as residents are not solely dependent on the often precarious services of EMBASA and do not need to resort to cisterns and wells.

According to Heller and Casseb (1995, cited in Gusmão 2008), cisterns have an important application in areas with high rainfall or, in extreme cases, in drought-prone areas where water is collected during dry periods. In Santo Estevão municipality, located geographically in the Polygon of Droughts area prone to prolonged drought periods, the local population also uses cisterns to address the water supply problem and the absence of water during certain periods of the year (Table 2).

According to Tavares et al. (2022), rainwater harvesting is a recommended management practice that offers various benefits, including reducing the burden on the public water supply system and serving as a potential solution to minimize the effects of increased runoff, especially in urban areas. Therefore, this collected water stored in cisterns will primarily serve domestic demand.
Table 2 - Some Forms of Water Supply Used by Residents in the Studied Areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>EMBASA (%)</th>
<th>Cistern (%)</th>
<th>Pit (%)</th>
<th>Other (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alto do Porrão</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mutirão</td>
<td>97</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Pau de Vela</td>
<td>85</td>
<td>5</td>
<td>19</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Developed by the authors based on the data collected in the research, 2013

The 'Mutirão' and 'Pau de Vela' neighborhoods use alternative means of water supply. In Figure 4, it can be observed that the 'Pau de Vela' area utilizes various sources of water supply: in addition to EMBASA, which has already been mentioned above, it also uses water from cisterns, artesian wells, and rainwater. In the 'Mutirão neighborhood, a small percentage of households resort to water supply from wells.

Figure 4 - Percentage of the main water supply sources in the studied areas

Source: Developed by the authors based on the data collected in the research, 2013.

The households in the studied areas that utilize alternative water supply should adopt certain measures to minimize health risks. Regarding the construction of a well, for example, the catchment area should typically be properly fenced, cleaned, and at least 15 meters away from any source of contamination, such as pit latrines, septic tanks, and sewage collection networks. However, during the interviews, it was noticed that the majority of households did not comply with the requirements described above; many residents claimed to be unaware of the basic measures for good construction, often digging the well too close to pit latrines and/or septic tanks.

Regarding rainwater harvesting, roofs and gutters should always be clean, and the reservoirs carefully sanitized to prevent favorable conditions for vector breeding in the water, such as the Aedes aegypti mosquito.
Figures 5, 6, and 7 depict the spatial distribution of various water supply methods in the municipality of Santo Estevão and the incidence of diseases related to the provision of such services in the studied areas.

Figure 5 - EMBASA Water Supply by the Population of the Urban Area of Santo Estevão and Disease Incidence in the Studied Areas.

![Figure 5](image)


Figure 6 - Cistern Water Supply by the Population of the Urban Area of Santo Estevão and Disease Incidence in the Studied Areas.

![Figure 6](image)


According to Figure 7, the majority of households in the urban area of Santo Estevão still rely on water from dug wells. Many residents state that due to the constant lack of water supply from EMBASA, groundwater wells are alternative sources to quench human and domestic animal thirst and for daily household cleaning. The incidence of
diseases in areas using dug wells is very high, and such values may be associated with improper handling by residents, as well as consumption without prior treatment, such as filtration and boiling, which could contain disease-causing vectors.

It is evident, therefore, that despite the majority of the areas being supplied by the Bahia Water and Sanitation Company, many inhabitants complain about this organization, alleging a lack of continuity in service provision for many consecutive days. Consequently, in some households, preference is given to using water from wells, and cisterns, among others, to meet their needs.

Figure 7 - Well Water Supply by the Population of the Urban Area of Santo Estevão and Disease Incidence in the Studied Areas

Figure 8 - Individual Percentage of the Studied Areas of Water Supply Methods


3.2 WATER TREATMENT FOR CONSUMPTION IN SANTO ESTEVÃO

The standard of portability for human consumption water is achieved through various treatment methods, with the greatest challenge being to choose the appropriate system for each specific situation.
EMBASA employs Water Treatment Plants (WTP) that operate through classical or conventional treatment, meaning that water is first sourced from the catchment area; then, in its raw state, it is conveyed through a pipeline to the Water Treatment Plant (WTP), where it undergoes several stages of impurity removal (coagulation, hydraulic flocculation, sedimentation, filtration, disinfection, and pH correction).

During the application of the questionnaires in the field stage, residents who generally use water from alternative sources of supply (wells, cisterns, rainwater) and even from EMBASA listed some of the water treatment methods for consumption adopted by them, such as chlorination, filtration, and boiling.

Chlorination consists of the disinfection process, namely the destruction of pathogenic microorganisms, using chlorine as the main compound. Chlorination prevents the proliferation of major infectious diseases, such as dysentery, cholera, and typhoid fever, among others. However, certain microorganisms like amoebas and Giardia (causing diarrhea) can resist chlorine, hence the need to filter water before drinking.

The filtration process, a method widely accessible and commonly used by the population, involves passing water through porous substances capable of retaining and removing some of its impurities.

The safest method of water treatment for drinking, in areas lacking other resources, is boiling (Cavalcante, 2012, p. 03). However, as it is a more time-consuming process, a large portion of the population still does not have the habit of boiling water for consumption. Additionally, the expenses incurred by many low-income families for cooking gas to boil water limit the use of this method.

From the analysis of Table 3, it can be observed that the population still has the habit of consuming untreated water, which can lead to many diseases due to inadequate water treatment. In Alto do Porrão, 49% of the interviewed individuals drink untreated water, directly from the tap; 10% use chlorine, 26% use clay filters, only 2% boil, and 13% use other methods (usually drinking bottled mineral water).

As observed in Mutirão, the highest percentage of residents (42%) use clay filters, and 38% consume untreated water. Nonetheless, in Pau de Vela, a significant portion of
households (30%) consume untreated water, while 57% filter it before consumption (Table 3).

### Table 3 - Water Treatment Methods for Consumption

<table>
<thead>
<tr>
<th>Areas</th>
<th>Five (%)</th>
<th>Filter (%)</th>
<th>Chlorination (%)</th>
<th>Natural (%)</th>
<th>Other (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alto do Porrão</td>
<td>02</td>
<td>26</td>
<td>10</td>
<td>49</td>
<td>13</td>
</tr>
<tr>
<td>Mutirão</td>
<td>0</td>
<td>42</td>
<td>03</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>Pau de Vela</td>
<td>10</td>
<td>57</td>
<td>05</td>
<td>30</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Developed by the authors based on the data collected in the research, 2013.

Through the analysis of Figure 9, one can perceive the distribution of various forms of water treatment for human consumption. The population of Alto do Porrão, for the most part, does not employ any means to treat water, consuming the resource in its natural state; a portion of the inhabitants consumes bottled water; a limited portion boils the water; whereas a considerable segment utilizes clay filters.

More than 50% of the residents of Pau de Vela use the filter, however, approximately 30% of the inhabitants ingest the liquid without treatment. The consumption of bottled water in Mutirão is higher than in the other analyzed areas; nevertheless, a significant percentage of residents drink untreated water (Figure 9).

Regarding the boiling of water for consumption, the inhabitants of the studied areas make little use of this technique. It is still possible to observe in Figure 9 that the residents of Mutirão do not boil water for drinking. All study areas use chlorine, albeit to an insignificant extent.

### Figure 9 - Percentage of Some Forms of Water Treatment for Human Consumption in the Studied Areas

![Figure 9 - Percentage of Some Forms of Water Treatment for Human Consumption in the Studied Areas](image)

Source: Compiled by the authors from data collected in the research, 2013.
Inadequate access to safe water and basic sanitation is one of the main causes of diseases worldwide (Boakye-Ansah et al., 2016). Thus, various diseases are diagnosed globally due to inadequate access to water, with the main diseases including diarrhea, dysentery, and cholera, among several others. According to the UN (2014), the incidence of diarrhea is responsible for thousands of annual deaths, mainly in children under five years of age.

The main diseases found in the studied areas, which may be related to water, are presented in Figure 10. The primary disease observed with the highest percentage was dysentery, with 70% of residents in Mutirão having had the disease. In Pau de Vela, this value decreases to 40% of the infected population, and in Alto do Porrão, it encompasses approximately 35% of the inhabitants with symptoms of the disease. It is worth noting that, in most cases, improper water storage is one of the main factors for the high rate of dysfunction in the population.

Some other diseases linked to inadequate access to safe water have isolated occurrences and/or low percentages, such as cholera, only diagnosed in Pau de Vela; hepatitis A occurring in both Pau de Vela and Alto do Porrão; and typhoid fever only found in Mutirão. Amebiasis is the second most frequent disease found in the three areas, with the highest incidence in Mutirão (Figure 10).

Figure 10 - Diseases Identified in the Areas of Alto do Porrão, Mutirão, and Pau de Vela - Likely Caused by Water Contamination

Source: Compiled by the authors from data collected in the research, 2013.
The best method to prevent water-related diseases, especially those linked to water consumption, is through its supply by a public network that provides water treatment, aiming for its distribution in quality and quantity. However, the inadequacy of this service offered to the population exposes them to diseases and disease-spreading vectors related to the water environment. As emphasized by Zhang et al. (2023), to prevent the proliferation of diseases, water treatment can occur through the method of washing or mechanical cleaning, which is useful for removing impurities adhered to pipes or increasing chlorine dosage to reduce microbial populations.

3.3 FORMS OF WATER STORAGE IN SANTO ESTEVÃO

Water destined for human consumption must be suitable for maintaining health, and for this, not only treatment but also water storage must be carried out properly (CAMPOS et al., 2003). In addition to storage, the population must also inspect and sanitize reservoirs to combat harmful pathogens to health.

Generally, reservoirs are used to store and preserve water for potential human needs. According to Heller and Casseb (1995, cited in Gusmão, 2008, p. 74), "distribution reservoirs allow storing water to meet the following purposes: meeting consumption variations; meeting consumption demands; maintaining minimum or constant network pressure."

There are several ways to effectively store water, with tanks being the most commonly used, but improper storage of this system can lead to diseases in inhabitants. Typically, households lacking adequate sanitation store water irregularly for internal consumption (Table 4).
Table 4 - Some Forms of Water Storage Found in the Domiciles of the Studied Areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Tank with lid (%)</th>
<th>Tank without lid (%)</th>
<th>Barrel (%)</th>
<th>Don't keep (%)</th>
<th>Other (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alto do Porrão</td>
<td>62</td>
<td>0</td>
<td>6</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>Mutirão</td>
<td>85</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Pau de Vela</td>
<td>89</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Compiled by the authors from data collected in the research, 2013.

The neighborhood that stores the most water is Pau de Vela, with 89% of the liquid reserved in tanks with lids; Alto do Porrão uses covered reservoirs in 62% of households; and Mutirão stores water in 85% of domiciles.

According to the table, other means of water storage are through tanks without lids, barrels, and others (such as PET bottles). In Pau de Vela and Mutirão, some residents use tanks without lids, respectively 9% and 5%; however, this type of reservoir is not safe and can become a vehicle for diseases, as insects and animals have easy access to the stored water. Similarly, barrels are also used by some people in the areas, often used incorrectly without proper material hygiene.

It is noted in the table that a considerable percentage of the population in Alto do Porrão (28%) does not have the habit of storing water and, for this reason, often suffer due to the constant lack of regular supply, which can be distributed with a frequency interval of days and even weeks without water from EMBASA.

It is necessary for tanks with or without lids, barrels, and PET bottles, among others, to be constantly sanitized for water storage, thus avoiding the proliferation of disease-causing vectors. It is worth emphasizing that the most appropriate form of water storage is the tank with a lid, thus avoiding the mosquito responsible for dengue, Aedes aegypti.

It is important to highlight that among the forms of water storage, tanks with lids are the most appropriate, as they reduce access by animals, insects, and contact with residues. Of course, it is important to constantly clean such reservoirs (Figure 11).
Figure 11 - Some Methods of Water Storage in the Studied Areas: (1) Tank with Lid, (2) Tank without Lid, and (3) Barrel

Source: The authors, 2013.

Figure 12 represents the percentage of the three analyzed areas regarding some forms of water storage by the population. There was unanimity in storing water in tanks with lids in the three studied areas, surpassing 50% of the visited households. Only in Mutirão is it possible to find various forms of storage. Thus, when services provided by EMBASA are not available, leaving residents without water, some inhabitants, by using various forms of water storage, manage to access it.

Figure 12 - Percentage of Various Forms of Water Storage in the Studied Areas

Source: Compiled by the authors from data collected in the research, 2013.
5 CONCLUSION

To alleviate the water supply situation and improve the quality of life of residents, some measures could be taken:

• Expansion of the water supply network and supply of water resources by EM-BASA in quantity and quality;
• Constant cleaning of water storage areas (tanks, barrels, pet bottles);
• Periodic cleaning of tanks, as well as creating the habit of covering them, preventing the proliferation of disease-causing insects.
• More investment by public authorities in policies that contribute to the proper functioning of the population's water supply, aiming, above all, at the population's quality of life to guarantee a healthier environment.
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