



TECHNICAL EVALUATION OF THE DESALINATION SYSTEM OF THE FRESH WATER PROGRAM IN THE MUNICIPALITY OF GRAVATÁ, PE

AVALIAÇÃO DO SISTEMA DE DESSALINIZAÇÃO DO PROGRAMA ÁGUA DOCE NO MUNICÍPIO DE GRAVATÁ, PE
EVALUACIÓN TÉCNICA DEL SISTEMA DE DESALINIZACIÓN DEL PROGRAMA AGUA DOCE EN EL MUNICIPIO DE GRAVATÁ, PE

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ABSTRACT

This study aims to evaluate the effects of the desalination system belonging to the Água Doce Program in a rural community in the municipality of Gravatá, semi-arid region of Pernambuco. For this, the methodology adopted was the use of cross-tabulation techniques of data in a GIS environment from the information collected in public platforms and technical reports, in which the spatial characterization of the region was carried out. In addition, a field visit was made, as well as contact with public agencies and the local community that benefited from this technology. Thus, it was evaluated that the system is extremely important for the community because there were benefits in the social and economic spheres. The amount of water refills through water tankers has decreased, there has been an improvement in the quality of the water through sensory reports from the families, and a decrease in water-related diseases. However, it was verified that the region lacks desalination technologies, moreover, an environmental impact related to the residual part of the desalination process was detected, the disposal of salt directly into the soil, causing its susceptibility through salinization.

RESUMO

Este estudo tem como objetivo avaliar os efeitos do sistema de dessalinização pertencente ao Programa Água Doce em uma comunidade rural no município de Gravatá, semiárido pernambucano. Para isto, a metodologia adotada foi o uso de técnicas de tabulação cruzada de dados em ambiente SIG a partir das informações coletadas em plataformas públicas e relatórios técnicos, onde foi realizada a

caracterização espacial da região. Além disso, foi realizada uma visita de campo, contato com os órgãos públicos e a comunidade local que foi beneficiada com essa tecnologia. Dessa forma, foi avaliado que o sistema é de extrema importância para a comunidade, pois houveram benefícios no âmbito social e econômico. A quantidade de recargas d'água através dos carros-pipa diminuiu, houve melhoria da qualidade da água através dos relatos sensoriais das famílias e a diminuição de doenças relacionadas ao uso da água. Porém, verificou-se que a região carece de tecnologias de dessalinização, além disso, detectou-se um impacto ambiental relacionado à parte residual do processo de dessalinização, o descarte do sal diretamente no solo ocasionando a sua suscetibilidade através da salinização.

RESUMEN

Este estudio tiene como objetivo evaluar los efectos del sistema de desalinización perteneciente al Programa Água Doce en una comunidad rural del municipio de Gravatá, región semiárida de Pernambuco. Para ello, la metodología adoptada fue el uso de técnicas de tabulación cruzada de datos en un entorno SIG a partir de la información recogida en plataformas públicas e informes técnicos, donde se realizó la caracterización espacial de la región. Además, se realizó una visita de campo, el contacto con los organismos públicos y la comunidad local que se benefició de esta tecnología. Así, se evaluó que el sistema es de extrema importancia para la comunidad, pues hubo beneficios en la esfera social y económica. Se redujo la cantidad de recargas de agua a través de camiones cisterna, hubo una mejora en la calidad del agua a través de informes sensoriales de las familias y una disminución de las enfermedades relacionadas con el uso del agua. Sin embargo, se constató que la región carece de tecnologías de desalinización. Además, se detectó un impacto ambiental relacionado con la parte residual del proceso de desalinización, el vertido de sal directamente en el suelo, provocando su susceptibilidad a la salinización.



1. INTRODUCTION

Desalination consists of a methodology used to remove most of the mineral salts from waters that are brackish, thus making them sweet, drinkable and, most importantly, consumable (Jones et al., 2019). There are several types of desalination systems: evaporation, reverse osmosis, multistage distillation and freezing, according to Mocock et al., (2018). Among the technologies mentioned, each one stands out in a different medium such as sea water or wells, presenting unique advantages and disadvantages. Therefore, the use of one or the other must be analyzed on a case-by-case basis.

Brazil has an average of 830 desalination systems with the capacity to feed 330,000 people. This program is in line with the United Nation's Sustainable Development Goals regarding Agenda 30. By 2030, the aim is to substantially increase water use efficiency in all sectors as a way to ensure sustainable withdrawals and the supply of fresh water to face water deficit and substantially reduce the number of people suffering from water scarcity (Jones et al., 2019).

To evaluate the desalination system, the municipality of Gravatá, in the state of Pernambuco, was chosen. It is located in the backcountry and is inserted in the delimitation of the semi-arid region of Pernambuco, which, in turn, has natural characteristics of water scarcity and climate variability. According to APAC data, in 2017, there were more than 7,300 artesian wells in the state of Pernambuco, of which 2,600 are located in Recife.

The present work aims to evaluate the effects of the desalination system for the treatment of saline or brackish groundwater that were implemented through the Água Doce Program in rural communities in the municipality of Gravatá, PE.

2. THEORETICAL FRAMEWORK

2.1 Water Scarcity in the Semi-arid Region

The semi-arid region is characterized by rocky soils, generally undeveloped as a result of intense and short rainfall, causing a decrease in the rate of chemical processes. The rivers present in this region are characterized as intermittent and are conditioned by the rainy season. Finally, its climate can be characterized by some factors such as high temperatures, variability and water deficit (Araújo, 2011).

The water deficit or scarcity in this region, as well as its interference in the life of the population, is constantly discussed, starting with the implementation of water policies such as damming, water transposition, well drilling, water capture and storage technologies (Stefanoski et al., 2013).

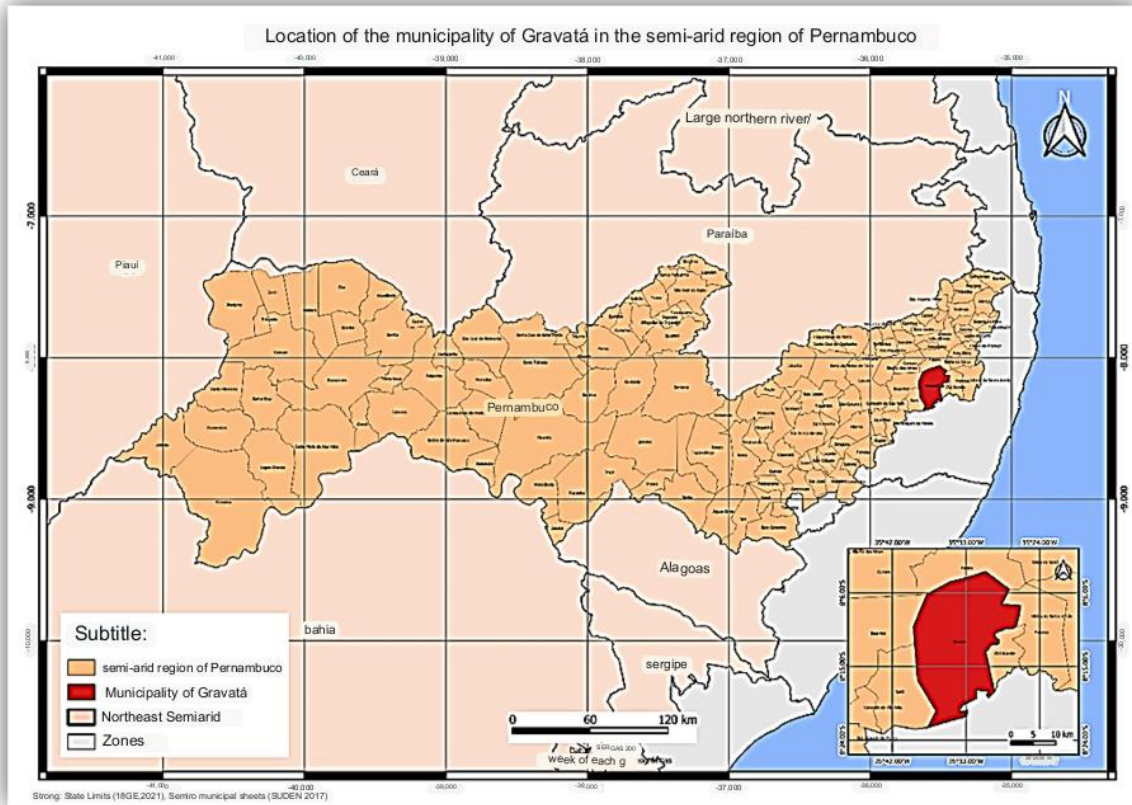
2.2 Semi-Arid Region of Pernambuco

Resolution 150/2021 published by the Deliberative Council of the Superintendence for the Development of the Northeast (SUDENE, in Portuguese) establishes the new delimitation of the Brazilian semi-arid region, increasing from 1,262 to 1,427 municipalities. The technical criteria used to choose cities are: high aridity index, average rainfall below 800 millimeters, water deficit above 60% and territorial continuity. These conditions have been established since 2005 and remain for the new delimitation in 2021.



Figure 1 shows the map with the municipalities belonging to the state of Pernambuco which are included in the new delimitation of the semi-arid region for the year 2021. In highlight, there is the location of Gravatá, the municipality chosen for this study.

Figure 1. Location of municipalities belonging to the semi-arid region of Pernambuco.



Source: Authors, (2023). Shapes available from SUDENE, (2021).

The semi-arid region of Pernambuco is made up of 123 municipalities, its area corresponds to 86,341 km² and it is estimated that its population has a quantity of 3,993,975 inhabitants (SUDENE Resolution 115).

2.3 Água Doce Program

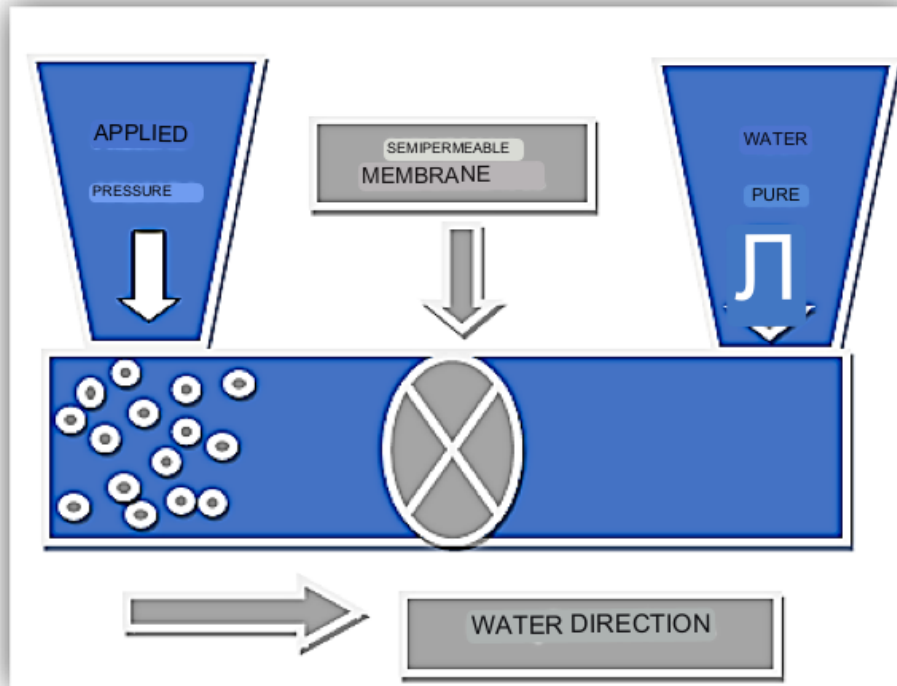
The Água Doce program is a joint action of public institutions and society and it is coordinated by the Ministry of Regional Development. This program aims to guarantee access to water for the population of rural communities located in regions with water vulnerability. From the capture of groundwater its treatment is performed through desalination systems, considering that the waters in this region have high amounts of mineral salts (MDR, 2020).

By 2020, the program had 840 desalination systems in operation, providing drinking water to rural communities in the states of Alagoas, Sergipe, Bahia, Pernambuco, Ceará, Piauí and Rio Grande do Norte. These systems have the capacity to produce about 3.2 million liters of drinking water per day and benefit nearly 320,000 people. They have as one of their components the reverse osmosis filter, which contains semipermeable membranes capable of removing mineral salts from brackish water and making it consumable (Brasil, 2020).



Reverse osmosis is a process that uses an external pressure higher than the osmotic pressure. The water passes through a semipermeable membrane, moving from a solution with high salt concentration to one with low or no salt concentration. The pressure exerted causes osmosis to occur in the opposite direction of natural osmosis, hence the name reverse osmosis (Ferraro, 2008). Figure 2 shows the reverse osmosis desalination process.

Figure 2. Reverse osmosis desalination process.



Source: Authors, 2023.

The membrane present in this system can be of different types, such as cellulose acetate, hydrazide polyamides, polysulfones, among others. Furthermore, the system needs modules, which can be hollow fiber, spiral and tubular (Ferraro, 2008).

3. METHODOLOGY

This is a bibliographical, exploratory and descriptive study.

It is bibliographical, since to gather information, scientific articles, magazines, laws, technical reports of the Fresh Water Program websites such as the platforms of Café/CAPES and National Water Agency (Hidroweb) were used. In order to analyze the number of artesian wells and desalination plant implemented in the region, data available on the Pernambuco Water and Climate Agency (APAC) website were used. Since it is a bibliographic research, it is inserted in the academic environment and is carried out from an investigation and study of works that have already been published, thus, seeking to improve knowledge (Amaral, 2007).

It is exploratory because it is a field research. A field visit was carried out to technically evaluate the operation of the desalination system in the municipality. Digital camera images were used. In addition, digital maps were created to characterize the municipality under study, a map of the Pernambuco semi-arid region from the new 2021 delimitation using the



free software Arc Gis from shapes available in digital platforms of the Northeast Development Superintendence (SUDENE). Exploratory research allows; therefore, the control of the researcher's distortion and it is based on reality as it is and not as the researcher may think it is (Piovesan & Temporini, 1995).

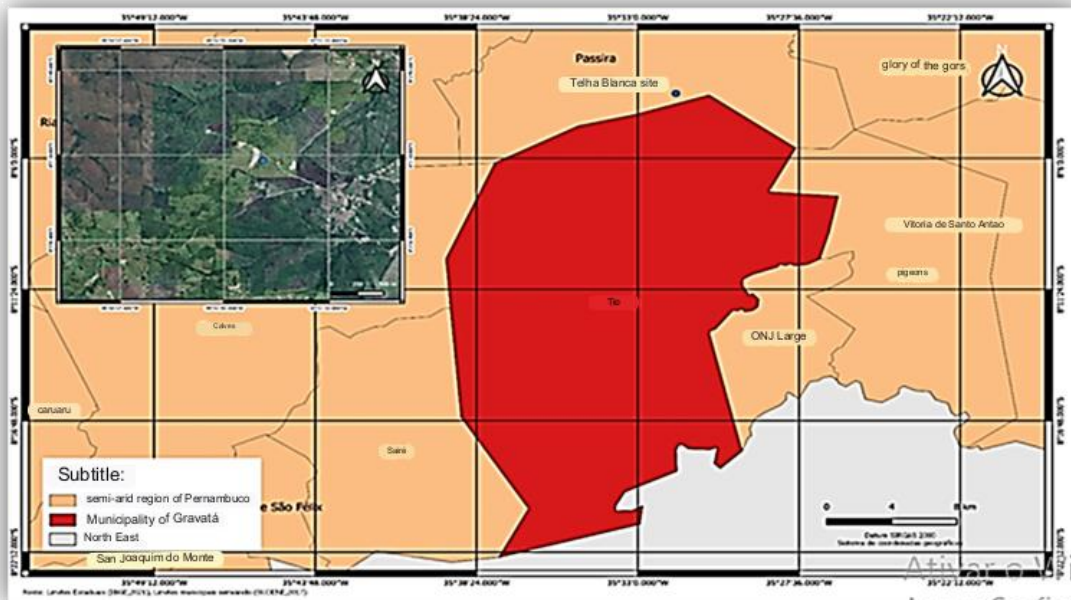
It is descriptive because, from the survey of quantitative data through technical reports, these were tabulated and presented in tables. Descriptive research is based on the relationship between variables or the description of the characteristics of a given population or phenomenon (Gil, 2002).

3.1 Characterization of the study area

The municipality of Gravatá-PE is located in a transition zone between the Sertão and the Zona da Mata, 81 km from the Pernambuco capital of Recife. It is located on the banks of the Borborema Plateau and has an average altitude of 447 m. As for vegetation, as it is in the transition zone, both Atlantic Forest and Caatinga specimens can be found. (Valença, 2015). The climate is considered semi-arid, influenced by the Serra das Russas which, with its height, causes orographic rains, preventing more abundant rainfall. The city has an area of 507,360 km², and a total population of 85,309 inhabitants (IBGE, 2020).

The community visited for the development of this study is the Associação de Telha Branca, located on the border between Gravatá and Passira. Figure 3 shows the map of the municipality of Gravatá, semi-arid region of Pernambuco, and the community that has the desalination plant from the Água Doce Program.

Figure 3. Location of the municipality of Gravatá-PE and the desalination plant in the Sítio Telha Branca community.



Fonte: Source, 2023. Shapes available from SUDENE, (2020) /Google Earth, (2022).

It is in this location that 80 families benefit from the desalination system, which is managed by the Associação de Telha Branca itself.



4. RESULTS AND DISCUSSION

The desalinator found at the Telha Branca site is the only one in operation in this region; the previous ones, which were implemented through the Água Doce Program, are in conditions of abandonment or deactivated.

On a visit to the site, based on the reports of the community farmers, it is observed the neglect of public agencies for this type of system, not providing conditions for repairs and maintenance. Table 1 presents the technical data proposed for the installation of desalination plants in the municipality, which are published in the Technical Report of the Água Doce Program for the year 2014.

Table 1. Forecast data from the Água Doce Program until 2014.

How much was the investment?	R\$ 168.000.000,00
How many desalination plants are planned to be installed?	1.200
In what period did this occur?	2010 a 2015
How many people would it benefit?	480.000 persons

Source: Document Base - Programa Água Doce (2012).

Some public agencies do not have updated data on how much was actually invested or how many desalination plants were implemented through the Água Doce Program for this region in the period from 2014 to 2022. In addition, no training is offered on how to perform the handling and maintenance of the system and how to collect water. Pinheiro et al. (2018) in their study detected that there was a lack of information on the part of the government regarding the storage of water, as it was stored in drums or pots without taps, which means that when capturing this water, it is prone to contamination.

Figure 4 shows some images of the components of the desalination system in the Sítio Telha Branca community.

Figure 4. Components of the desalination system at Sítio Telha Branca.



Caption (from left to right): a) Water storage tank with a capacity of 5,000L; b) Complete panel of the desalination system; c) Desalter control buttons; d) Pressure gauges and Rotameters and e) Desalter pump.

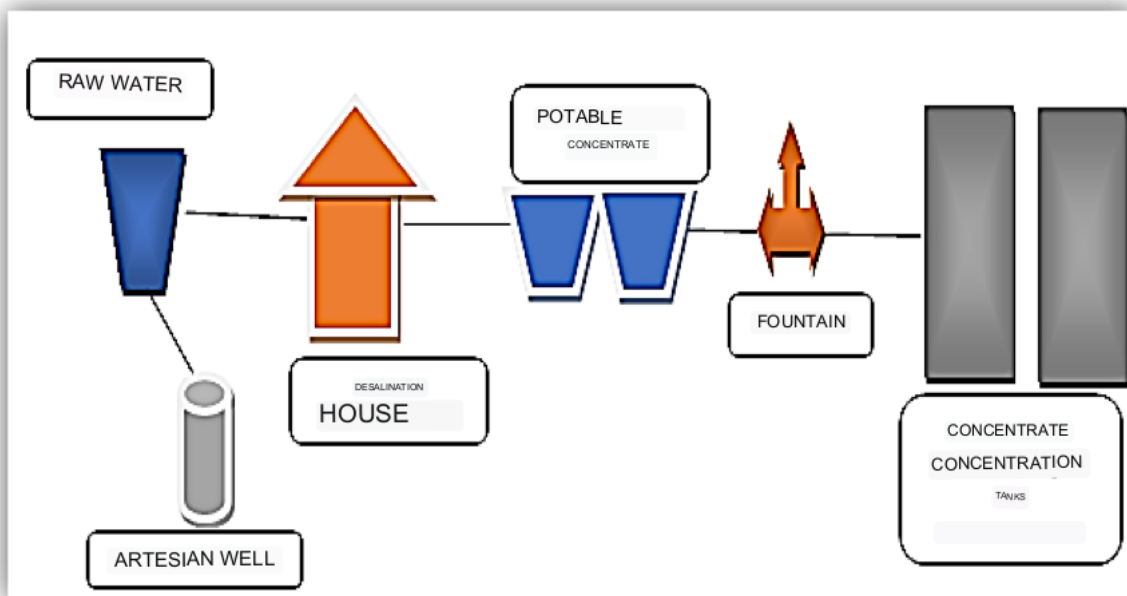
Source: Authors, 2023.



The desalinator was installed in mid-2001. Its installation was financed by the State Government. It can benefit around 80 families that are located in the community of Telha Branca, and daily an average of 50 liters of water are collected. This water is used for the most diverse purposes (drinking, bathing, cooking) etc.

This system receives brackish water from the artesian wells through an auxiliary pump, which passes it to the particle retention filter and, subsequently, to the high-pressure pump. The higher the amount of salt, the higher the pump pressure. This is where the membranes are fed, then the permeate and concentrate volumes are separated, which generally have 70-80% of permeate and 20-30% of concentrate, this amount is seen by the rotameter. The volume that is used by the population, the permeate, is stored in a reservoir that has a capacity of 5,000L to be made available to the community. Figure 5 shows the operating stages of the reverse osmosis desalination system, which is similar to the Água Doce Program desalination system.

Figure 5. Stages of operation of the desalination system.



Source: Authors, 2023.

Even with the importance of this system for those families, some difficulties were still presented to keep it working, its maintenance costs and the purchase of filters, for example, are maintained by the community. The system operates through three-phase energy which is also paid by the community. Sustainable development is based on social, economic and environmental aspects and requires actions that show respect for nature, in which politics plays a fundamental role (Sachs, 2008).

Table 2 presents the costs for environmental sustainability in this municipality in a study proposed in the Base Document Água Doce Program in 2012.



Table 2. Proposed costs for environmental sustainability in the implementation of desalination plants.

Unit costs related to the environmental sphere of the desalination plant	Value (R\$)
Technical and environmental diagnosis	21.949,62
Environmental sustainability	5.433,61
Unit costs related to the environmental sphere of the installation of the Production Unit	Value (R\$)
Technical and environmental diagnosis	9.134,00
Environmental sustainability	12.276,00
TOTAL	48.793,23

Source: Base Document – Água Doce Program (2012).

The residual part, that is, the mineral salts removed in the process by reverse osmosis, are discarded in a clay pit located behind the system, so they are not used or stored in specific places. This is an irreversible environmental impact that damages the soil, causing salinization. The residues, when used correctly, could contribute to fish farming, cattle feeding, among others. In the study conducted by Netto Júnior and Silveira (2014) in the irrigated perimeter of Moxotó agrovila VIII, the residual part of desalinated waters is used in tilapia (*Oreochromis niloticus*), fish farming as well as in the irrigation of halophyte plants. Thus, generating jobs and contributing to the sustainable process.

According to the reports of the residents of Sítio Telha Branca, the desalination plant improved their quality of life. Before they depended more frequently on water tanker refills to meet their needs. After the implementation of this system, there was a decrease in dependence on water refills. The study by Azevedo (2012) points out that the desalination system breaks the political dependence on tank cars and other sources of water under private domain. Before these cars and water from the dam were used for their supply; and after installation of the desalination plant, this was no longer the case.

It is also noteworthy that there has been a decrease in diseases resulting from contaminated water, thus being an effective technology in health prevention. According to reports from the community health agents, desalinated water prevented (and prevents) the appearance of many diseases. Reports on the sensory perceptions of residents regarding water quality consider it superior in comparison to mineral water, however, its quality may be compromised, as residents do not have specific buckets for collecting water. Azevedo (2012) indicates that desalination can promote an improvement in quality of life. It can be observed with the decrease in the incidence of diseases, the improvement of water quality and the decrease in dependence on tank trucks; these are significant gains for the community.

In rainy periods, the community has technologies for capturing and storing water (cisterns), and they alternate their consumption between cistern water and desalinated water. However, the collection of desalinated water is carried out using buckets, which can cause the water quality to be compromised.

5. FINAL CONSIDERATIONS

Based on the above considerations, one can see the importance of the desalination system for rural communities, therefore, it is of utmost importance to expand this policy to benefit more communities, thus being a great help in living in regions with water vulnerability.



This social technology is capable of providing a little water autonomy for rural families, especially during periods of drought, as well as enabling a significant improvement in quality of life, since the water is of good quality and used for various purposes.

For the semi-arid region of Pernambuco, the closest municipality that has only one desalination plant is Gravatá. This is considered worrying, as these are municipalities within the delimitation of the semi-arid region. Therefore, it is necessary initiatives from federal entities for the development of water policies for this region.

The importance of this policy is based on the Desalination Incentive Law, approved in 2015 by the Environment Commission (CMA). It is based on the fact that the northeastern semi-arid region has a very large amount of underground brackish water, which, if treated with a desalination plant, enables an effective water access policy. The improvement in quality of life is reiterated, as well as the reduction of water refills and diseases for rural families benefiting from this technology.

Finally, there is a need for environmental education actions, in order to further improve the sustainable effects of this system, since it was observed that the community makes the irregular disposal of the residual part of the water desalination process. This study is considered a bibliographic support to raise discussions between public agencies for the proposition and improvement of water policies, such as desalination plants to be implemented in this region.

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