Revista Brasileira de Recursos Hídricos
Brazilian Journal of Water Resources
Versão On-line ISSN 2318-0331
RBRH, Porto Alegre, v. 27, e33, 2022
Scientific/Technical Article

https://doi.org/10.1590/2318-0331.272220220027

Scenario and water supply diagnosis for human consumption in the municipality of Aracati, Ceará

Cenário e diagnóstico da oferta hídrica para o consumo humano no município de Aracati, Ceará

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Received: March 25, 2022 - Revised: October 19, 2022 - Accepted: October 19, 2022

ABSTRACT

Aracati, a municipality in the State of Ceará, is experiencing water shortages. The unpredictability of rainfall and a lack of management of these resources worsen water scarcity. The work diagnosed water availability in the municipality to aid municipal water planning. The secondary data was precipitation, drilling wells, and water bodies mapped in Google Earth Pro®. The municipality presents a severe drought and has a poor water-to-land ratio. The 19 operating wells intended for human use have a daily output estimate sufficient to supply water to 65% of the local population. A further 23 wells are inactive, contributing another 20% to the groundwater supply deficit. Concerning water quality, there is fresh water in 23% of the wells, saline water in 25%, and brackish water in 52% of the wells. Therefore, it is critical to focus on managing and supporting projects for the sustainable use of water resources.

Keywords: Groundwater; Water body; Public supply.

RESUMO

Aracati, município do Estado do Ceará, apresenta problemas hídricos. A escassez de água é agravada pelas irregularidade de chuva e, também, pela falta de gestão desses recursos. O trabalhou realizou um diagnóstico da disponibilidade hídrica no município fornecendo suporte no planejamento hídrico municipal. Utilizou-se os dados secundário de índices pluviométricos e poços de águas subterrâneas. O Google Earth Pro® foi usado para mapear as massas d'água. O município apresenta forte seca e baixa relação água-terreno. A avaliação de produção diária dos 19 poços ativos, destinados ao consumo humano, têm capacidade para abastecer 65% da população local. Outros 23 poços encontram-se desativados, causando um déficit de mais 20% da oferta hídrica subterrânea. Quanto a qualidade da água, 52% dos poços apresentam água salobra; 25%, água salgada; e 23% água doce. Portanto, ressalta-se a importância de gerir e promover iniciativas de uso sustentável dos mananciais hídricos.

Palavras-chave: Águas subterrâneas, Massas d'água, Abastecimento público.

INTRODUCTION

Brazil is a wealthy country regarding total water availability, but water scarcity is exacerbated by the spatial distribution of water, the unpredictability of rainfall, the growing demand for water, a lack of infrastructure, and a lack of public awareness. (Agência Nacional de Águas e Saneamento Básico, 2020).

The country experienced a drought in 2017, affecting around thirty-eight million people. Around 80% of individuals impacted reside in the Northeast, and 55.5 percent of the total records are from Bahia, Ceará, and Pernambuco. Droughts and shortages afflicted more than twenty-two million people in Brazil in 2019, over eleven times the number of people affected by floods. Drought's effects are not always noticeable but tend to spread throughout the country. Drought's effects are broad and likely to happen nationwide (Agência Nacional de Águas e Saneamento Básico, 2018, 2020; Machado Neto et al., 2019).

Ceará's climate is affected by a precipitation regime characterized by variation in rainfall distribution both spatially and temporally (Souza Filho, 2018). Droughts have always been a concern for the State, particularly in the "Sertão Central" region, where the effects of water scarcity are more visible (Ceará, 2018).

Ceará has been experiencing one of the worst droughts ever recorded, with rainfall below the historical average since 2010, according to data from the *Fundação Cearense de Meteorologia e Recursos Hídricos* (FUNCEME) [Ceará Meteorology and Water Resources Foundation]. The low annual rainfall has resulted in a water crisis, threatening water availability in springs and reducing the volume of water bodies to the point where rivers are arid.

Groundwater supply becomes increasingly important during droughts. In Ceará, well drilling increased by 40% per year between 2012 and 2018. This water well deployment rate coincides with the last great drought, which lasted from 2012 to 2017 (Nunes & Medeiros, 2020). However, the wells' organization, management, and supervision are insufficient. If human activities and the inherent vulnerability of aquifers are not considered, human and environmental health are compromised (Uechi et al., 2016).

The water issue in Ceará is due to unpredictable rainfall patterns, high surface spring evaporation rates, and low crystalline rock storage capacity (Costa, 2022). The State's territory comprises a 70% crystalline basement (Silva et al., 2007); however, the coast of Ceará includes alluvial and coastal sediment formed by dune systems, paleodunes, and Barreira's formation, whose aquifer potential is high.

The Jaguaribe river estuary is located on Ceará's east coast and is part of the Low Jaguaribe hydrographic sub-basin, with the river serving as the State's main watercourse. Water sources generated by the basin's aquifer systems include the Potiguar sedimentary basin, alluvial deposit, crystalline rocks, and dunes (Companhia de Gestão dos Recursos Hídricos, 2019).

Over 32 years, significant changes were observed in the coastal communities of Low Jaguaribe, with disordered urban growth, potentialized anthropic activities, and a lack of investment in basic sanitation by local or State governments (Borges, 2017; Oliveira, 2018). These modifications affect the properties of water resources, causing issues with both the supply and water demand of a certain quality and quantity (Lima et al., 2010).

Even though the dams and reservoirs are intended to boost water availability, given the region's climatic circumstances and causing water scarcity, they lead to a reduction in freshwater flow and, consequently, a significant saline intrusion in the Jaguaribe river estuarine region (Carvalho et al., 2017; Cavalcante, 2019). As a result, several effects occur, including changes in the hydrological regime and physicochemical quality of the water, nutrient retention by dams (Rios, 2018; Braga & Matushima, 2021), upstream mangrove migration following saline intrusion, and riverbank erosion due to a lack of sediment retained upstream of the estuary (Godoy & Lacerda 2013, 2014; Borges, 2017).

The municipality of Aracati, Ceará, developed along the Jaguaribe river's banks roughly fifteen kilometers upstream from the river's mouth. Surface water salinization in this area makes it unsuitable for irrigation, drinking, and other uses. In order to minimize this issue, it is vital to use groundwater for municipal supplies (Bezerra Diniz, 2018).

The involvement of public authorities in the effective and fully implemented management to ensure the municipal water supply is of the utmost importance. The quantity and quality of available surface and groundwater for municipal water supply must be monitored. In light of this, this study aimed to examine the water availability scenario in the municipality of Aracati-CE and contribute to research that can aid in managing these crucial resources.

MATERIALS AND METHODS

The study area's characteristics

Aracati is a municipality near the coast in the northeastern part of the State of Ceará. It covers an area of 1,227.197 square kilometers (Figure 1) (Instituto de Pesquisa e Estratégia Econômica do Ceará, 2018). In the 2010 census, the resident population was 69,159 people, with a predicted population of 75,392 in 2020 (Instituto Brasileiro de Geografia e Estatística, 2021).

Aracati also has The Municipal Human Development Index (IDHM) of 0.655 (Atlas do Desenvolvimento Humano no Brasil, 2020). The municipality ranks 166th in the State, with only 4.5 percent of households having adequate sanitation (Instituto Brasileiro de Geografia e Estatística, 2021). The primary economic activities include tourism, fishing, agriculture, sand, clay, diatomite, and oil mining (Rangel, 2019).

Aracati has an irregular rainfall regime, with a short rainy season (January to April) and an average rainfall of 935.9 mm, as well as a semi-arid tropical climate with average temperatures ranging from 26 to 28 degrees Celsius (Instituto de Pesquisa e Estratégia Econômica do Ceará, 2018).

Sedimentary covers and alluvial deposits are two distinct hydrogeological domains in the region. The Barreiras Formation sediments constitute a zone with pronounced faciological variation, with more and fewer permeability levels intercalations, resulting in different hydrogeological parameters depending on the local context. These differences result in various groundwater productive potentialities. This local setting lends the Barreiras Formation aquitard features. Despite this, its utilization is quite advanced in some regions.

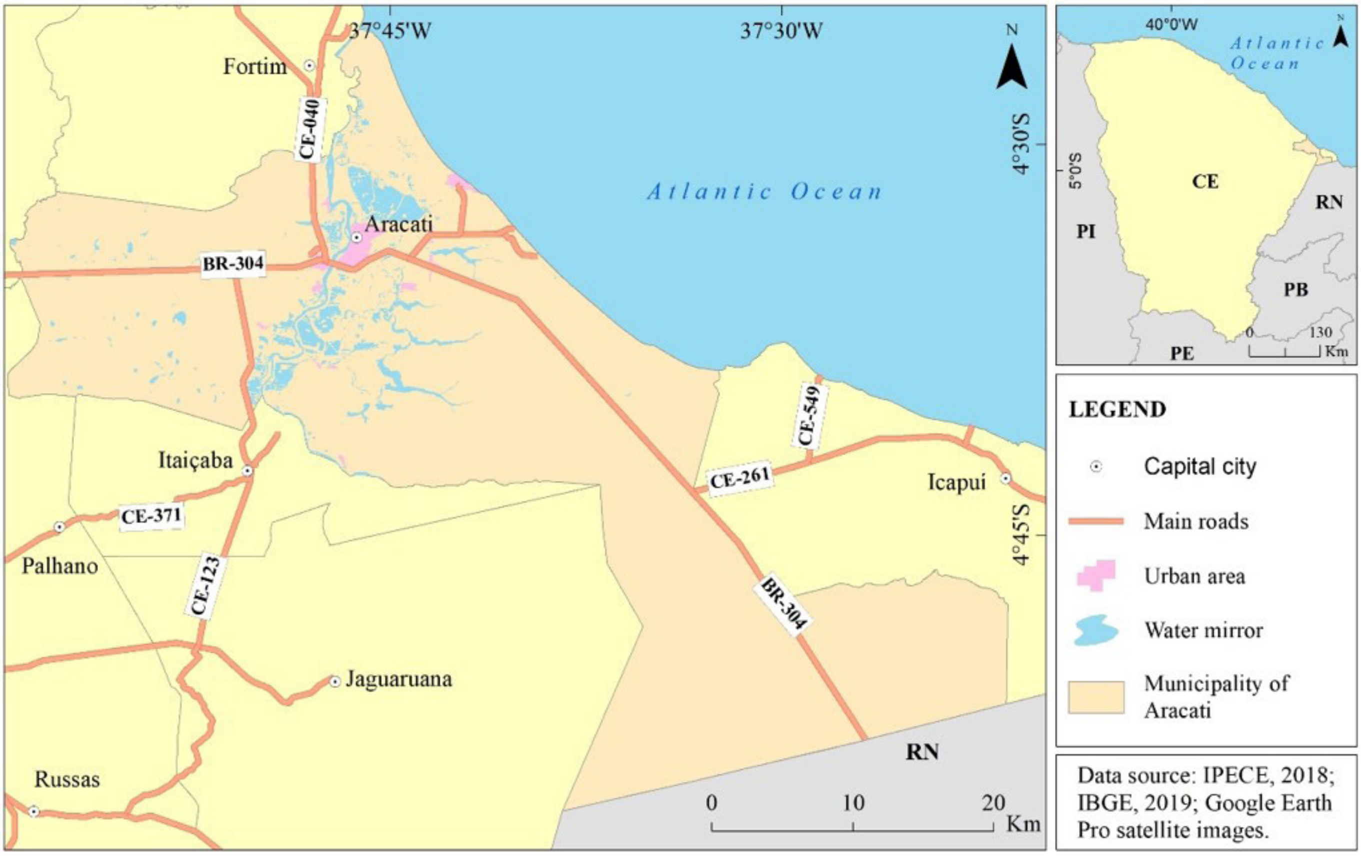

Figure 1. Location map of the municipality of Aracati, Ceará.

On the other hand, the dunes are a geological unit with considerable aquifer potential, with flows of 5 to 10 m^3/h. Recent sandy-clay sediments occur along the channels of the major rivers and streams that drain the region, making alluvial deposits a viable alternative as a source with high relative importance from a hydrogeological standpoint. In most cases, the high permeability of sandy terms compensates for their thin thicknesses, resulting in large flows (Vieira et al., 1998).

Procedures for methodology

The municipality of Aracati's surface and groundwater supplies, as well as essential study topics like climate, geology, and saline intrusion in surface waters, were reviewed in the literature. Following that, the acquisition of secondary data from government platforms and public entities was completed: data on rainfall for the municipality throughout time from FUNCEME; data sheet of wells registered from *Sistema de Informação de Águas Subterrâneas* (SIAGAS) [Groundwater Information System]; vector data on the municipality of Aracati's delimitation from IBGE.

The pluviometry data utilized in this study aided in developing the region's hydroclimatological balance. In addition, using the Google Earth Pro® software, which is unrestricted, polygons were demarcated to map and classify the municipality's aquatic bodies. The polygons determine the following information: reservoir type, latitude, longitude, perimeter (km), and area (km^2). The image utilized is from the second half of 2021, and the viewpoint is from a height of about 1.4 kilometers.

The database from the SIAGAS has the following data important for this work: coordinates, the well's location and usage, the well's depth, stability flow, water analysis date, and electrical conductivity (EC). The EC product in natural waters and a good factor for a hot climatic zone, whose value is 0.65, were used to obtain total dissolved solids (TSD) values (Hem, 1985; Fundação Cearense de Meteorologia e Recursos Hídricos, 2020).

The recorded values of the physical-chemical parameters for each well in the SIAGAS database are on different analysis dates, making it difficult to get sufficient information for an interpretation when considering the same period of data collection in the field.

Sturges' (1926) statistical approach was used to analyze the data, which allowed the number of classes, amplitudes, and interval sizes to be defined to conduct a consistent study of the data.

The data was entered into a Georeferenced Information System (GIS) and used to create thematic maps with spatial software. The Inverse Distance Weighting (IDW) interpolation method was used to create the depth map as a raster. Because the distribution of wells in the municipality is well-spatialized, the values were extrapolated and clipped with the municipal boundary.

The acquired data were processed to assess the region's precipitation conditions, the quantity of existing surface water bodies, the supply potential from surface water sources, and the groundwater quality. This data will be helpful for municipal water planning and future research on monitoring and managing water resources in the region. Similar research was conducted for the State of Piauí (Vasconcelos et al., 2014) and the municipality of Russas, Ceará (Mendes et al., 2021).

The study raised essential questions about regional water supply issues and the importance of managing water sources.

RESULTS AND DISCUSSION

Analysis of pluviometry data

There is just one rainfall station in the municipality of Aracati: The Aracati station, whose data was used to create the 46-year history series. The latest 40 years (1981–2020) were used in this study. The rainy season in this series has an average annual precipitation of 918.65 mm, with the highest rainfall of 2,654.10 mm recorded in 1985, and the lowest annual rainfall of 220 mm recorded in 1993 (Figure 2).

In 2012, the State of Ceará experienced the worst recent drought, with accumulated precipitation of just 363.8 millimeters. This situation contributed to many of the population suffering from water access. In 91% of the cities in Ceará, the water crisis was severe (Costa, 2022). From 2012 to 2017, the State of Ceará had many municipalities in a state of emergency owing to drought (Machado Neto et al., 2019). Throughout this period, no considerable precipitation occurred, which is harmful to the recharge of the reservoirs (Costa, 2022).

The State of Ceará has an average annual precipitation value of roughly 800 mm (Fundação Cearense de Meteorologia e Recursos Hídricos, 2020). In this regard, the municipality is clearly above the state average. The rainy season in the municipality has been concentrated between January and July for the 40-year history series, accounting for more than 97% of the annual precipitation (Figure 3).

July marks the start of the dry season, which lasts until December. This scenario has an impact on the annual precipitation in the region. The rainfall indices were thus categorized into seven intervals using the Sturges method to identify the classes (Table 1).

The municipality of Aracati has experienced drought for the past 11 years, with the most severe years being 2012 and 2016, classified as severe droughts. The region saw five rainfall events that fell into the typical severe rainy (in 1984, 1986, and 1988) and heavy rainfall (in 1985 and 2009).

The data indicate that over half of the season ranges from severe drought to normal drought and low annual precipitation rates range from 220 to 942.1 mm. Prolonged periods of drought exacerbate the region's water crisis. Surface waters in certain regions tend to dry up or reach critical levels due to drought, depending on the size of the water bodies (Mendes et al., 2021).

Hydrography and water body mapping

The water bodies mapped in the municipality total 858 and are dispersed throughout the territory. These water bodies include surface waters, weirs, anthropogenic reservoirs (e.g., aquaculture ponds), and lagoons. The municipality has 93.7% of these water bodies concentrated on the alluvial plain. Water bodies account for

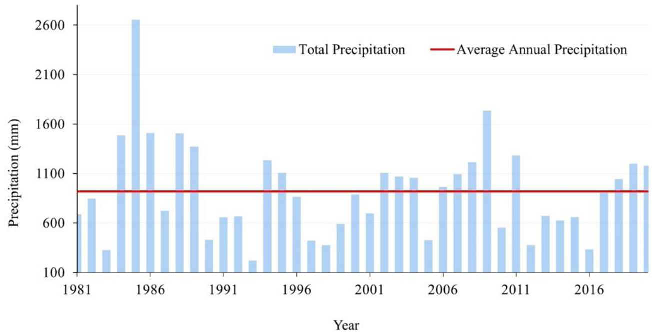

Figure 2. The historical series of annual rainfall averages from 1981 through 2020 in Aracati (obtained from Fundação Cearense de Meteorologia e Recursos Hídricos, 2020).

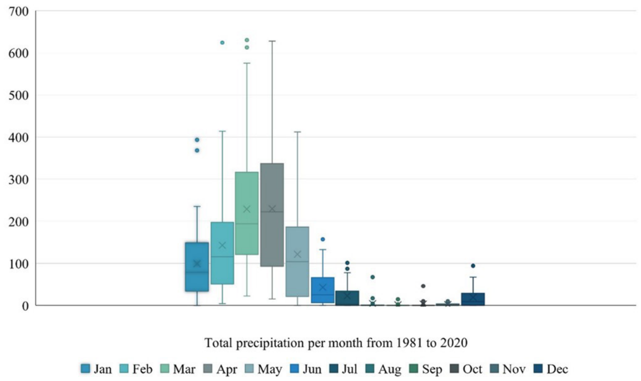

Figure 3. Precipitation (mm) in Aracati for the 40-year history series (obtained from Fundação Cearense de Meteorologia e Recursos Hídricos, 2020).

Table 1. Frequency histogram (obtained from FUNCEME's data 2020).

Precipitation (mm)			Classification	%
220	⊢	460.7	Severe drought	20
460.7	⊢	701.4	Moderate drought	22.5
701.4	⊢	942.1	Normal drought	12.5
942.1	⊢	1182.8	Normal rainy	20
1182.8	⊢	1423.5	Moderate rainy	12.5
1423.5	⊢	1664.2	Severe rainy	7.5
1664.2	⊢	2654.1	Rainy	5

4.12% of the municipality's total area in the research area. Water bodies cover an area ranging from 0.016 to 731.412 hectares. Based on the coverage of the areas and integrated into the GIS to examine the distribution of water bodies, four groups were formed using the Sturges technique (Figure 4).

The map shows the classification of slightly more than 90% of the water bodies in the research area, with a predominance of very small and small bodies. This observation shows that the municipality of Aracati frequently has a water crisis during dry spells, which jeopardizes the water potability of the municipality's water resources and, consequently, the quality of life for the local population. Natural reservoirs account for around 40% of the municipality's reservoirs, with the remainder being fabricated reservoirs used for commercial (shrimp and fish farming) and recreational purposes (Figure 5).

As noted by Carvalho et al. (2017) and Cavalcante (2019), dams and reservoirs increase the retention of saline water in the Jaguaribe river estuary, particularly during drought years, compromising the recharge of surface springs and influencing the physicochemical quality of the water. This situation raises concerns about water availability for urban supply from natural springs.

The factors (low precipitation, scarcity, water crisis, and salinization of the waters) that have been examined thus far highlight the significance of managing water resources, and the rational exploitation of underground springs meets the population's needs and promotes sustainable development in the municipality.

Data analysis from the SIAGAS

The physical characteristics of wells

A survey conducted in the municipality of Aracati found 594 wells, with a well's density of close to 0.5 wells per km^2. In the database, 547 wells present final depth information: 42% of the wells range from 30 to 60 meters; 24% are shallow wells, ranging from 5 to 30 meters; 23% range from 60 to 100 meters; 4 are deeper wells with more than 100 meters; 8% present no data (Figure 6). According to the estimated population in 2021, there are 127 residents per well in Aracati.

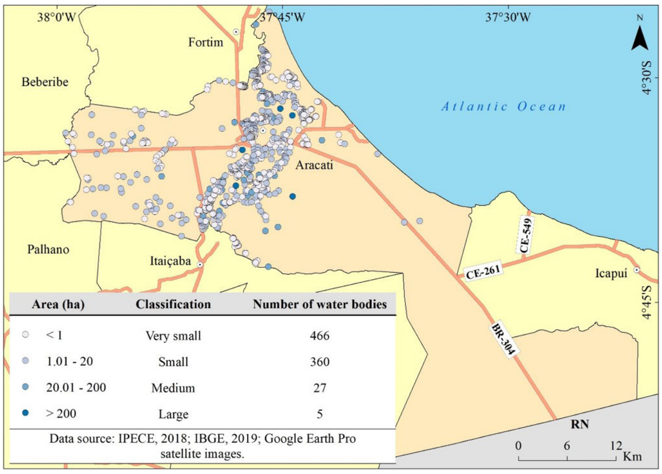

Figure 4. Surface classification of water bodies as a function of hectares.

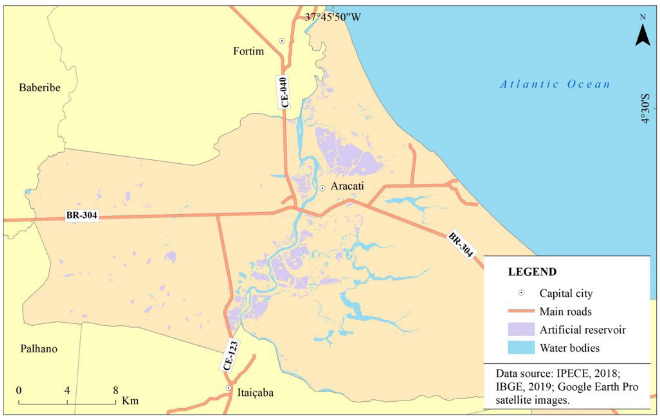

Figure 5. The Aracati's water bodies map.

There are 583 tubular wells registered with SIAGAS, ten dug wells, and one point type well. The hydrogeological distribution of these wells shows that five are in the fissure domain, thirty-six in the karst domain, seventy-nine in the sedimentary domain, and nine in multiple domains. Lithological profiles are present in 22% of these registered wells.

The graph in Figure 7 generated using SIAGAS data depicts the current State of the region's catchment works. Only 52 percent of the municipality's 594 wells are operational.

The most common use for wells is irrigation (49%), followed by industrial water supply (17%), livestock (14%), recreation (8%), urban water supply (5%), and domestic supply (2%). Some wells do not provide information (5 percent). Irrigation wells can be found to the east of the municipality due to a lack of surface water bodies, increasing farmers' demand for groundwater.

Well productivity in the Aracati municipality

The average daily water consumption per person in the country was 154.9 liters in 2018, an increase of 0.5% over 2016. Consumption in the Northeast ranged from 115.4 liters per person per day to 182 liters per person per day in the Southeast during

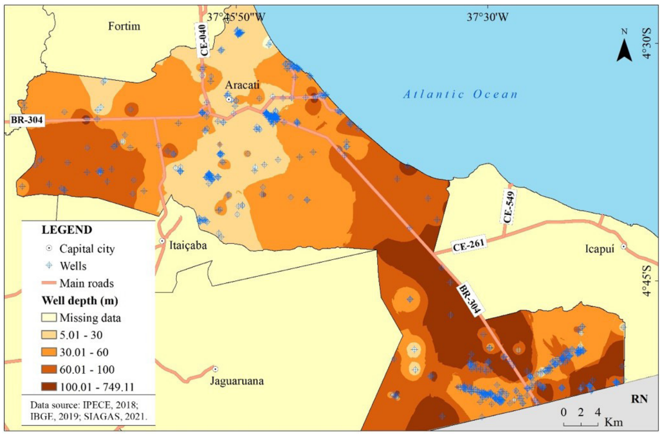

Figure 6. The spatial distribution of SIAGAS-registered wells in Aracati.

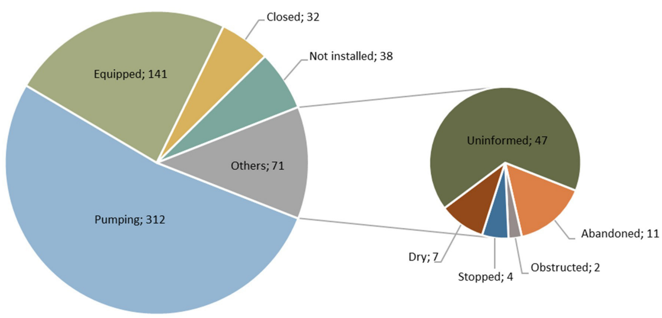

Figure 7. The recorded situation of the wells, Aracati-CE (obtained from Serviço Geológico do Brasil, 2021).

the same year (Brasil, 2005). A total daily output of 8,700.2 m^3/day is required for the municipality to supply the population based on consumption in the Northeast.

The total daily production of the Aracati wells was calculated, as well as the number of people who could be served in the municipality, using information from the wells' constructive profiles: a) the situation of the wells, filtered by wells in use (pumping); b) the purposes of abstracted water, which are intended for human consumption and registered as urban supply and domestic supply; c) well stability flow.

In Figure 7, there are 312 wells in operation, but only nineteen are intended for human use and have registered flows (Table 2). *Companhia de Água e Esgoto do Ceará* (CAGECE) [The Water and Sewage Company of the State of Ceará] provides fourteen (14) of these wells, which operate 24 hours a day and have a total flow of 4,963.4 m^3/day, enough to supply up to 43,011 people (57%).

Obtaining information about the pumping time was impossible for the five remaining wells. Therefore, an arbitrary analysis of possible operation scenarios with production values and the number of inhabitants served is presented in Table 3.

In the worst-case scenario, the wells operate 4 h/day, providing up to 330.4 m^3/day and supplying more than 2 thousand people. In the intermediate scenario, the wells operate 6 h/day, producing 495.6 m^3/day and supplying more than 4 thousand people. The municipality gains almost 8% of the water supply to the population in the scenario for 8 h/day with operating wells. Therefore, the 19 currently active wells can supply up to 65% of the population, considering the average daily consumption of 115.4 liters/inhabitant/day.

A second evaluation was performed for deactivated wells for human consumption (both equipped and uninstalled). There are twenty-three wells in all. These wells were also evaluated in the context of three alternative groundwater exploration scenarios, as shown in Table 4.

The short-duration scenario (4h) contributes to the supply of more than 7 thousand people, adding 75% of the municipal population to the already active wells. The medium duration scenario (6 hours) can supply 15.3% of the population. In the best scenario, it is estimated that the municipality's maximum water supply would increase by about 1,770.8 m^3/day, or about 20% of the municipality's minimum water supply. In this way, the active wells and possible ones could supply up to 85% of the population of Aracati.

Table 2. Flow stabilization of CAGECE's active wells intended for urban supply (obtained from SIAGAS data 2021).

ID	Number of registered wells	Flow (m^3/h)	Flow (m^3/day)
01	2300005158	10.28	246.72
02	2300005159	12	288
03	2300005194	8.52	204.48
04	2300005195	8.8	211.2
05	2300005196	8.34	200.16
06	2300005197	8.42	202.08
07	2300005198	7.2	172.8
08	2300005199	8.25	198
09	2300019950	15	360
10	2300019951	12	288
11	2300022125	18	432
12	2300022126	30	720
13	2300022127	30	720
14	2300022128	30	720

Source: Serviço Geológico do Brasil (2021).

The physicochemical characteristics of groundwater collected in the municipality

According to the SIAGAS database of wells registered for the municipality, there were ninety-four records of water analysis in the second semester with electrical conductivity (EC) values in 1998. Figure 8 depicts the spatial distribution of EC values in the municipality.

The electrical conductivity (EC) values range from 140 to 55000 μS.cm-1, with the highest concentration in an alluvial deposit well. The aquifer type and the presence of pollutants from anthropogenic sources affect the ion concentration in water. Even though the collected database lacks information about aquifer types, the implications can be generated and related to depth data (Figure 6) and information about geology (Figure 8).

The easternmost alluvial deposits and dune regions have the lowest EC values. As can be observed, the values in these regions do not go above 1400 $\mu S.cm^{-1}$. These wells may be drawing water from these porous aquifers, as they have depths ranging from 5 to 30 meters in alluvial deposits and 30 to 60 meters in dune areas.

There are wells of varying depths, reaching over 100 m. These wells may draw water from the Barreiras or Jandaíra aquifer, or both, and dissolve salts that increase the conductivity value.

Table 3. The five operating domestic supply wells' stability flow (obtained from SIAGAS' data 2021).

ID	Number of registered wells	Flow (m^3/h)	(4h/day)	(6h/day)	(8h/day)
15	2300031345	16.5	66	99	132
16	2300031347	16.6	66.4	99.6	132.8
17	2300031353	16.5	66	99	132
18	2300031355	16.5	66	99	132
19	2300036664	16.5	66	99	132
Summation			330.4	495.6	660.8
Inhabitants supplied per day			2,863	4,295	5,726
Percentage of people served (%)			3.8%	5.7%	7.6%

Source: Serviço Geológico do Brasil (2021).

Table 4. "Stability flow" for deactivated urban and domestic supply wells (not installed and equipped) in the three scenarios (obtained from SIAGAS data 2021).

ID	Number of registered wells	Flow (m^3/h)	(4h/day)	(6h/day)	(8h/day)
20	2300001912	10	40	60	80
21	2300001914	10	40	60	80
22	2300005139	1.2	4.8	7.2	9.6
23	2300005143	6.5	26	39	52
24	2300005145	1.5	6	9	12
25	2300005146	1	4	6	8
26	2300005150	3	12	18	24
27	2300005164	12	48	72	96
28	2300005167	5	20	30	40
29	2300005185	3	12	18	24
30	2300005187	1.2	4.8	7.2	9.6
31	2300005189	3.5	14	21	28
32	2300005190	3	12	18	24
33	2300005193	35	140	210	280
34	2300005274	7.54	30.16	45.24	60.32
35	2300005301	30	120	180	240
36	2300005302	30	120	180	240
37	2300005308	5	20	30	40
38	2300005313	2.6	10.4	15.6	20.8
39	2300010651	2.4	9.6	14.4	19.2
40	2300010652	7.92	31.68	47.52	63.36
41	2300021747	20	80	120	160
42	2300021748	20	80	120	160
	Summation		885.44	1328.16	1770.88
	Inhabitants supplied per day		7,673	11,509	15,346
	Percentage of people served (%)		10.2	15.3	20.4

Source: Serviço Geológico do Brasil (2021).

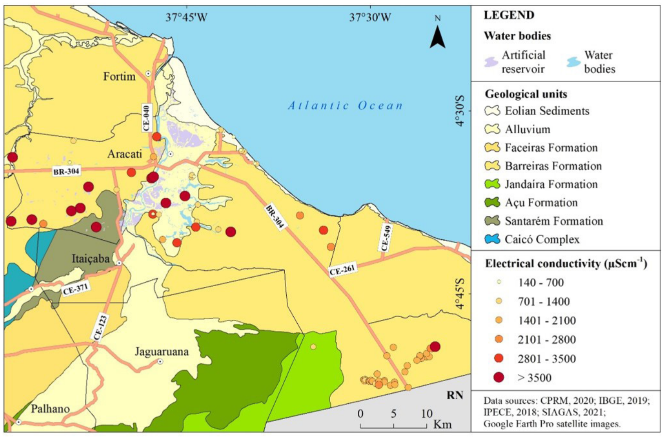

Figure 8. Electrical conductivity spatial distribution in the region (obtained from Serviço Geológico do Brasil, 2021).

The EC concentration ranges from 1400 to 2800 $\mu S.cm^{-1}$, with a sample exceeding 3500 $\mu S.cm^{-1}$ in the municipality's easternmost area, close to the state border.

The western portion of the municipality has a higher concentration of EC. This increase may be related to the crystalline aquifer catchment, as these are deeper wells over 60 m deep. However, there are shallower wells located in the alluvial aquifer that have high EC. Due to the high EC concentrations, this situation necessitates studies such as physical-chemical analysis of the groundwater, the study of stable isotopes to analyze the interaction of natural surface water with groundwater, and water quality monitoring.

The following characteristics are essential in evaluating the current and future scenarios of aquifers affected by salinity: (a) salinity sources, (b) processes that affect the geochemistry of affected aquifers, (c) saltwater movement, and (d) dimension of interaction with groundwater systems (Keesari & Dauji, 2021). Groundwater in coastal areas is susceptible to salinization by seawater intrusion. This situation makes groundwater unsuitable for human consumption or irrigation (Gopinath et al., 2019; Nogueira et al., 2019).

As observed, in Aracati, the well waters in the dune zone that are more susceptible to marine intrusion have values up to 1400 μScm^{-1}; on the other hand, wells situated in the inner area of the municipality have much higher conductivities. This context opens debates and investigations about the infiltration of waters altered by anthropogenic activity.

The Ministry of Health Ordinance Nº 888/21 does not present reference content for EC. However, the conversion of EC to Total Dissolved Solids (TDS) shows that these are predominantly ionically rich waters. Twenty-six samples of water from the analyzed wells, intended for domestic and urban supply, have TDS concentrations higher than the maximum allowed by Ordinance Nº 888, which is 500 mg/L (Brasil, 2021).

Table 5. Water classification according to estimated TSD values established by CONAMA Resolution Nº 357/2005 (Brasil, 2005).

Intervals	Classification
0 a 500 mg/L	freshwater
500 a 1.500 mg/L	brackish water
> 1.500 mg/L	saltwater

The TSD intervals for classification are in Table 5. According to the water classification for Aracati in 1998, 52% of the ninety-four wells with documented values contain brackish water, 25 percent salt water, and 23 percent fresh water.

Due to the domination of sedimentary lands, the municipality of Aracati has high hydrogeological potential. In addition, the low investment in basic urban sanitation and the high natural vulnerability of sedimentary aquifers change the physical-chemical characteristics of water resources, causing problems with both water quality and quantity.

Groundwater quality is protected by monitoring physical-chemical and biological parameters, making it necessary to analyze its use and minimize health risks. Natural processes, such as geological formations, substantially impact groundwater quality fluctuations, but human activities can also significantly impact (Selvakumar et al., 2017).

CONCLUSIONS

Prolonged droughts are a defining feature of the municipality of Aracati, as shown by the analysis of the historical series (1981-2020). The study shows that only 4.12% of surface springs cover the entire municipality, and just over 90% of water bodies are very small and small bodies. The scarcity can seriously jeopardize the recharge of water resources and promotes a collapse in the water supply and the physicochemical quality of water.

Surface water distribution in the municipality of Aracati demonstrates the representativeness of water bodies in the municipality's economic development due to fish and shrimp farming. With successive droughts, strategic wells must be deployed to increase supply and demand and promote initiatives for the sustainable use of underground and surface water resources.

The study of the arbitrary well pumping scenarios enabled us to conclude that the municipality can ensure that up to 85% of the population can be provided with minimal daily consumption (115.4 liters per person per day) with sufficient planning, control, and monitoring of the wells.

As an estuarine region, Aracati presents saline intrusion in the groundwater. This observation is reflected in the water quality, where 52% of the wells present brackish water, 25% salt water, and only 23% fresh water. Besides, there are anthropic contributions that can cause significant variations in salinity.

Overall, the municipality has the potential for urban supply; however, some wells capture compromised water that needs adequate treatment for consumption. This observation highlights the importance of managing water resources to satisfy the residents' demands and monitoring water quality to avoid health problems.

The work laid a solid foundation for the municipality's water management and established boundaries for sustainability. Since our work will be based on secondary data, it is advised that the information on field activities be updated to depict the current status of the municipality.

The information acquired can then be used in field activities for various purposes, including water resource preservation, risk assessment of water bodies and reservoir structure, and well recovery.

ACKNOWLEDGEMENTS

The authors would like to thank the Federal University of Ceará's Department of Geology, the Geoprocessing Laboratory of Ceará (GEOCE), and the Graduate Program in Geology for providing the necessary infrastructure, as well as the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) [National Council for Scientific and Technological Development] and the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) [Coordination for the Improvement of Higher Education Personnel].

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Editor-in-Chief: Adilson Pinheiro

Associated Editor: Michael Mannich