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Water Supply Situation Diagnosis in Salvador, Bahia, Brazil

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Abstract

Large urban centers face great challenges to meet the needs of a growing population among these challenges to water is one that has generated many conflicts, highlighting the issue of urban water supply, which should afflict humanity over the next 20 years. This paper analyzes the situation of the current water supply model of the city of Salvador, Bahia, Brazil and its metropolitan area, scheduled for 2030 that is guided on the central axis, and almost unique, water fountains available in the Joanes River (Joanes -I dams and Joanes -II), the Rio Cobre (Copper Dam), the Rio Ipitanga (Ipitanga -I dams , Ipitanga Ipitanga -II and III), the Jacuípe River (Dam St. Helena) and Paraguaçu River (Dam Pedra do Cavalo), enclosing an available flow planned for 2030 of 20.87 m^3 / s, greater than the total water demand projected for 2030 of 18.32 m^3/s

Keywords: water supply – Salvador City (BA), Water demand management, Urban water supply, Environmental sustainability

1 - Introduction

The significant increase of the population in urban areas leads to large demands for infrastructure and supply services. As an example of this growth has been the city of Salvador. Bahia, Brazil. According to the IBGE 2000 Census in the 1990s, the city received around 368,000 new inhabitants. This number exceeds the total population of Vitoria da Conquista city, third in population in the state of Bahia, with about 308,000 inhabitants estimated in October 2007. Also according to the IBGE estimates for the period 2000-2007 was in Salvador, an increase of approximately 450,000 inhabitants. This number is close to that of population of Feira de Santana, the highest among the cities in the state, estimated at 570,000 inhabitants. With the consequent increase in area built to house the new population groups, expanding up in this way, waterproof surface, which in turn aggravates flooding. This growing trend of big cities will continue demanding more effort, investment and natural resources such as water, essential for humans. It is also expected, an increase in pressure on the use of natural resources such as water, resulting not only from increased global urban population, but also consumer habits. So there will be greater demand for water systems and increase energy expenditure of networks. According to the SEA (2008), it is estimated that becoming more efficient supply systems power would decrease the energy expenditure which is a significant percentage of municipal budgets in the developed world. The metropolitan area of Salvador (RMS), also known as the Great Salvador, was established by the Federal Complementary Law No. 14 of 8 June 1973. With about 3,884,425 inhabitants (IBGE, 2012), is the third metropolitan area more populated Northeast Brazil, after the Metropolitan Region of Recife and Fortaleza and the seventh of Brazil, and is the 109th most populous in the world. Includes Camaçari, Candeias, Dias d'Ávila, Itaparica, Lauro de Freitas, Dare deus, Mata de São Joao, Pojuca, Salvador, São Francisco do Conde, São Sebastiao do Passé, Simões Filho and Vera Cruz citeis. (Figure 1). Contextualizing in general urban population distribution within the 5,565 Brazilian cities and their urban seats, it appears through the Atlas Brazil (2010), that a significant portion of the urban population is concentrated in municipalities with a population density of more than 250 thousand inhabitants.

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This universe predominantly located in the metropolitan areas and the coastal region, corresponding to a total of 77 municipal seats, representing about 42% of the total projected population for the year 2025. Within this universe, is inserted the city of Salvador with a current population of about 2.711 million, according to the IBGE census (2012). On the other hand, the group of municipalities with less than 50,000 inhabitants is also an important part of the total population (32%) in the same horizon, being distributed in 5,153 urban seats (93% of total). The remaining 26% of the population in the same year, 2025, correspond to the resident portion in municipalities with populations between 50,000 and 250,000 inhabitants, represented by 335 seats. The results of the study in the total universe of Brazilian municipalities, Atlas Brazil (2010), with the basic objective of analyzing the water supply to the Brazilian urban population and propose alternative techniques for security of supply to all municipalities in the country, indicated that 2,506 (45%) of the municipal seats have adequate supplies. There are 52 million people with 2015 service assurance However, 3,059 municipalities (55%) may be short supply, due to problems with the supply of spring water (surface and / or underground) in quantity and / or quality or the ability of producers systems, or for both reasons. These urban seats, 46% require investments in producing systems, within that percentage is included Salvador and its metropolitan area, and 9% have deficits resulting from water availability in water sources used. Within the context related to supply problems detected in the universe of Brazilian municipalities and considering the projection for 2015, only Minas Gerais, Espírito Santo, Mato Grosso do Sul and Rio Grande do Sul have populations with lower future demands of their current populations.

As to the evaluation of types of springs used for water supply in the states and municipalities, it is observed that most makes use of surface waters, however the supply using groundwater is quite significant, and in the Northeast is the highest percentage. In addition to several regional contrasts, there is evidence of a number of peculiarities of the states and municipalities, the following main aspects among which: 61% of Brazilian municipalities are supplied by surface water sources, whose reality is compatible with high availability surface water (computed at 91,000 m3 / s) and flow rates with 95% retention. Out of this, 47% of urban seats are serviced exclusively by surface water sources, especially in the states of Espírito Santo, Rio de Janeiro, Pernambuco and Paraiba, where 467 municipalities are supplied only by such sources. In the states of Acre, Amapá and Rondônia (Northern Region), Alagoas, Bahia, Ceará and Sergipe (Northeast Region), Goiás and the Federal District (Midwest Region), Minas Gerais (Southeast Region) and Santa Catarina (South Region) the main water sources are also superficial; Table 1 summarizes this information.

2 - Use Current Underground Water in Salvador

Despite being used with some frequency since colonial times, the aquifer system Salvador has been little studied. The groundwater Crystalline Alto region is used by many government agencies and by the population as a supplementary means of supply (Nascimento, 2008) .The tertiary economic, such as trade in general, the hundreds of service stations, in addition to the bus companies and trucks, construction, cooling, cleaning houses, among others, have served these groundwater resources. The aquifer system Salvador High Crystalline has a water reserve with the potential of the order of 1.7 x 107 m3 / year, enough to meet the consumption of a population of 250,000 (Lima, 1999). However, these reserves can reach a much larger volume, which adds to its economic importance and its strategic reserve, (Nascimento, 2008). According to Lima (1999), the possible lateral connection to the aquifer system of the Recôncavo, through zones of fracturing the transverse fault Salvador, could extend this reserve. However, the existence of fan-conglomerates well cemented the Salvador formation prevents the hydraulic coupling between the two systems in the border region of the fault line that separates the lower town uptown. In addition, the sedimentary formations of the Recôncavo Basin that occur in the lower part of the city of Salvador are predominantly pelitic nature, known considered storing weak and groundwater producers. They consist of shales, and turbidites sandstones calcilutites the Candeias Formation and a pelitic-carbonate sequence of Pojuca Formations. The São Sebastião formation is an excellent aquifer, only makes direct contact with the High Crystalline in the municipalities of Simões Filho and Camaçari, located north of Salvador. The importance of aquifer economic potential of the High Crystalline Salvador to groundwater is mainly controlled by a diverse geological environment marked by variations in lithology and tectonic structures. The Crystalline aquifer is characterized as fractured aquifer, where groundwater storage in fractures and cracks, which translates into random and discontinuous reservoirs, small extensions. In this context, in general, the flows produced by the aquifer are small. These define a hydrogeological potential down to the rocks, without, however, diminish its importance as an alternative of supply, in the case of small communities or as current and future strategic reserve. This aquifer is responsible for dozens of historical sources of Salvador (surges), which although not observed, some even offer the natural beauty of colonial times.

The role of government is critical in the recovery of urban and social functions of artistic and cultural heritage, in collaboration with the communities that still use. The aquifer San Sebastian, following which constitutes an aquifer for use in large, located in the Recôncavo Sedimentary Basin, has been studied as a function of their water resources and the quality of its waters, which implies significant economic importance. Its importance has been considered after Petrobras deployment in 1953, the Aratu Industrial Center in 1967, the Camaçari Petrochemical Complex and in 1975, more recently, with the implementation of Ford's vehicle assembly in 2001. They are important users of groundwater: the companies in the Camaçari Petrochemical Complex; the Bahia Water and Sanitation Company of SA (EMBASA) - State water utility; Autonomous Water and Sewer Service Alagoinhas (SAAE); Petrobras, with its various oil fields; beverage companies installed in the metropolitan area of Salvador and Alagoinhas and other smaller industries; aviaries and cold, not to mention the table waters marketing sector (bottled drinking water), that is, are those with normal levels of minerals. The State of Bahia stands out on the national stage for the excellence of groundwater resources of the aquifer of San Sebastian, belonging to the Recôncavo Sedimentary Basin, present in sandy sedimentary terrain. These factors allow the ground to filter almost all impurities, leaving the crystal clear waters and soft.

The importance of the aquifer San Sebastian is given especially in its multiple uses: in full public supply cities of Camaçari, Dias D'Ávila, Pojuca, São Sebastião do Passé and Mata de Sao Joao, belonging to the metropolitan area of Salvador, in addition the cities of Catú and Alagoinhas and numerous villages; the supply of petrochemical, metallurgical, automotive; the thermoelectric to generate energy and drinks water. Striking examples of the importance of the aquifer São Sebastião, are the uses of Alagoinhas springs and Dias D'Ávila as raw material in food industry. The fountain located in Alagoinhas, 119 km from Salvador, is recognized not only for its water quality - proven by physical-chemical and bacteriological, but also by the volumes available, using only 25% of its reserves to supply the municipality of Alagoinhas. The aquifer characteristics of São Sebastião and the quality of its waters were decisive factories for install of the beverage industry in Alagoinhas and Dias D'Ávila municipalities. Schincariol, the Kirin Group, was the first brewery to reach Alagoinhas, for 15 years, but others continue to invest in the region, the recent investment example made in the city with an estimated yield from this year, 600 million liters of beer. In 1957, the bottler of water Dias D'Ávila was installed in the city later became home to other bottlers of mineral waters. With the discovery of the therapeutic characteristics of the Imbassaí River waters, Dias D'Ávila was elevated to Hydro-mineral category in 1962, the quality of its mineral water and came to be regarded Residential area and proper location for the treatment of skin diseases due to the medicinal mud found in the river. Since then, its water became bottled and marketed.

Due to the water quality of the aquifer São Sebastião companies have the utmost care in preserving the mineral components sourced from nature. To achieve this goal, the water passes through stages of filtering to retain the insoluble minerals, without going through any chemical process in order not to lose their mineral properties (A TARDE, 2013). Despite these aquifers if they constitute a strategic reserve for the city, the potential and effectively installed availability, types and quality of its waters are relatively unknown in its entirety. Although the use of groundwater in Brazil is significant, the exploitation continues to be made empirically. In many states of the federation, the improvised and uncontrolled use of this feature results in frequent problems of interference between wells, reducing the rivers of base flows, impacts on wetlands (marshes) and reducing sources of sources of discharges. In the state of Bahia, this situation is no different there is not yet an overview of the use of groundwater, primarily for use in human consumption. It is necessary to increase knowledge of groundwater resources, from a scientific basis and multidisciplinary studies, so that we can have a real evaluation of the potential of its waters in the context of water resources used to supply the metropolitan area of Salvador. This knowledge can support the management of groundwater, avoiding irreversible damage to aquifers, arising inserts of urban occupations in the areas of occurrence of aquifers in shaping the current mosaic that is the major urban center of the metropolitan area of Salvador. The availability of groundwater, in fact, could play a key role in economic and social development of the region, from a general understanding of the potential of these features on sustainable development of the region. The CERB - Hydro Power Company and Sanitation Bahia has a database that puts the state of Bahia in particular the studies on groundwater. However, you do not have a joint concept and paid for refills, the stored volume, production, consumption, in addition to the quality of the water, in order to supplement the supply of the population.

In the case of collapse of the official system of city supply, the waters of the wells located in the urban area, should not be consumed without quality control and treatment. In the case of the metropolitan area of Salvador, the abandoned wells can compromise water quality. According to the database of CERB, the Camaçari accounts for about 16 abandoned wells. There are many abandoned wells in Salvador and Mata de Sao Joao without an accounting of these constructions latter two municipalities, all of these wells are drilled in the field of detrital Roofs and Crystalline Basement while in Camaçari in the Sedimentary domain, whereas the territory of that municipality is almost entirely on sedimentary rocks of the geological basin Recôncavo (Santos and Oliveira, 2007). The major problem related to abandoned wells is that this case can be constituted as preferred routes of contamination to groundwater. According to Pacheco & Rebouças (1982) the well-built operated and abandoned without control both at the federal state or municipal level, turn into true focus of groundwater contamination. The possibility of use of groundwater resources "in nature" in other less noble uses is very important because it prevents the consumption of water treated by the Bahia Water and Sanitation Company of SA (EMBASA), which should have a nobler destiny in supply and domestic use, particularly for the urban population residing in the Greater Salvador. The importance of this water reserve for future generations can be associated with a possible need for water supplementation for the growing population, combined with the prospect of shortages and contamination of the product in surface water sources, located more distant from urban boundaries of the region metropolitan city of Salvador.

3 - Current Use of Water from Dams

Existing surface water availability in the state territory are inserted in 13 Watershed as the Freshwater Programme 2010-2019 (BAHIA, 2010) highlighting the basins of the rivers Itapicuru, Accounts and Paraguaçu, being exclusively Bahia. At last, is located Dam Horse Stone, responsible for water supply approximately 60% of the population of Salvador and Metropolitan Region, and Feira de Santana and the main cities of the tobacco producing region, such as Waterfall, Castro Alves, Cruz das Almas, Maragogipe, Muritiba, São Gonçalo dos Campos, São Félix, Sapeaçu, among other municipalities in the Recôncavo, according Mesquita & Oliveira (2003). Historically, dams were planned and built for the purpose of water supply, irrigation and flood control. In the late nineteenth century, hydropower and navigation have become additional uses of dams. As civilizations developed, grew the needs of water supply, irrigation, flood control, navigation, water quality control, sediment control and energy. Recreation is sometimes included in benefit of the population. Throughout history, the dams have been built to collect and store water and regulate the flows. This picture is also repeated in the metropolitan area of Salvador (RMS), where dams have played significant role in the storage and management of water needed to sustain its population growth and most likely will continue throughout the beginning of the XXI century. Also, throughout this century, major changes will occur in the water supply sources, such as the rain water use by many countries, including RMS and Brazil. The most significant Streams used for the RMS supply are: Rio Paraguaçu (Pedra do Cavalo Dam), Rio Joanes (Dams and I Joanes Joanes II) and Rio Jacuípe (Santa Helena Dam). Dams River Ipitanga, Rio Joanes, Horse Stone (Rio Paraguaçu), St. Helena (Rio Jacuípe) and Copper are responsible for supplying the water consumed in the RMS and are enclosed in Environmental Protection Areas - APAs, encompassing several watersheds. Those areas of great economic and environmental value, include several rich ecosystems biodiversity and natural resources (such as the Atlantic Forest, mangroves dunes, rivers), which in recent years have suffered environmental damage due to expansion of human activities, Table 2, according with the Municipal Plan for Basic Sanitation - PMSB (SALVADOR, 2010). Concerned about the situation of supply sources in the metropolitan region of Salvador, Bahia Company of the Water and Sanitation SA - EMBASA through the MTO (Production Department of the Superintendent of the Metropolitan Region), has been constantly performing inspections in the areas of APAs Joanes / Ipitanga Copper / St. Bartholomew and Horse Stone, to identify the main impacting activities in the environment that can affect the quality and quantity of water of these springs.

3 - Rain Water as Alternative Source

The capture and use rainwater is an ancient technique proven through reservoirs excavation records up to 3000 BC, such as the rain water use for toilet flushing the Palace of Knossos on Crete, about 2,000 BC (Tomaz , 2003). In Brazil, the oldest facility was built by North Americans in Fernando de Noronha Island in 1943 (Carlon, 2005). Today, around the world, the use of rainwater as an alternative source has become an effective way to address the problem of water shortages in some areas. In the city of Salvador there are no programs for rainwater capture, requiring a more detailed study for the use of these water resources. An embryonic model that can be expanded based on the user experience is applied by the educational conglomerate College Antonio Vieira, situated in Garcia's neighborhood.

This educational institution has made great changes in its structure taking advantage of the roofs of buildings, capturing rainwater that is stored in large tanks. These waters are used for cleaning, toilets and gardens and is therefore marked the monetary economy and the consumption of water supplied by the state company.

4 - Conclusions

From our discussions, it is concluded that the current model of urban water supply in the city of Salvador and its metropolitan region urgently needs to be rethought. Urge individualize the dispensing operation, separating the treated water from operational use of water, which need not be potable characteristics. You must also review the prevailing logic in which it is believed that the solution to distribution problems will come only through great works and water resources is only water flowing from rivers. The growth of urban centers continues to escalate and the consumption of natural resources grows without planning.

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Figure 1: Schematic Map of Salvador Metropolitan Region

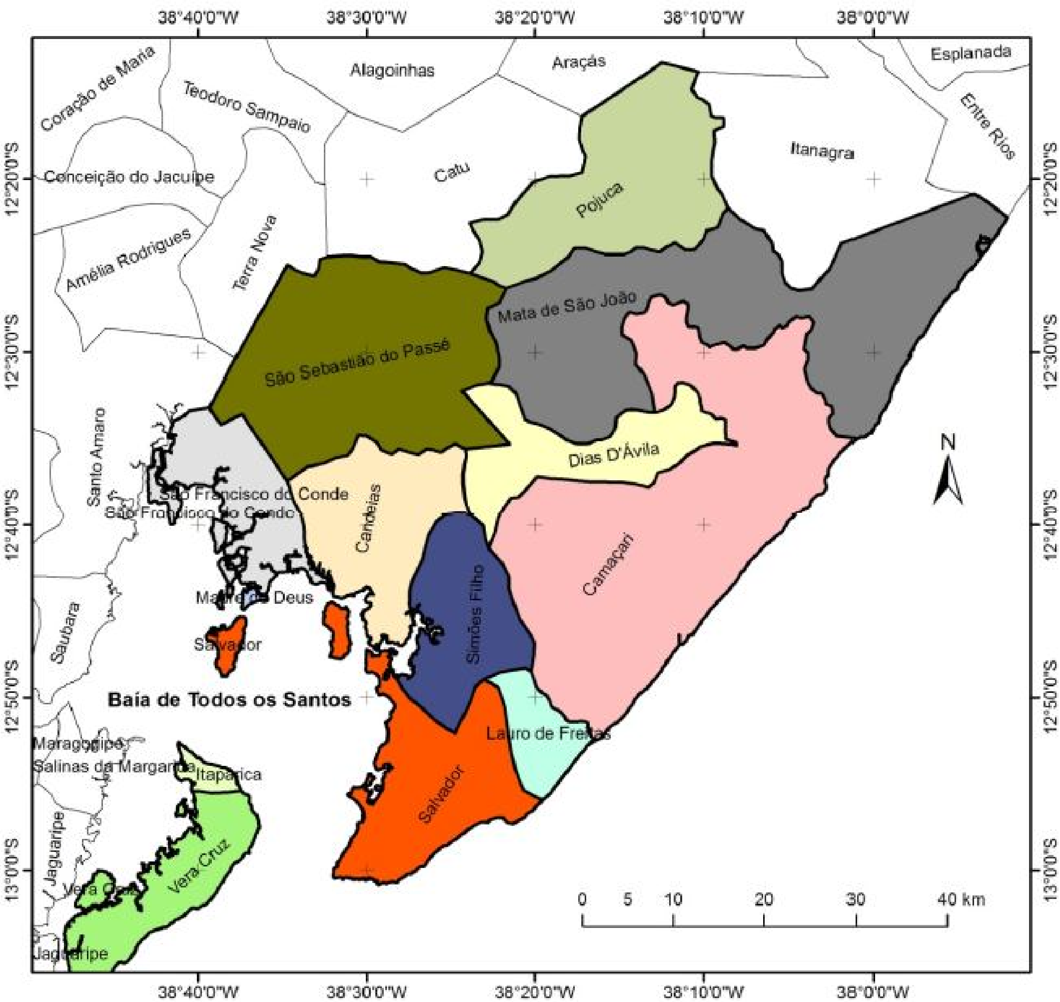

Table 1: Urban Headquarters Supplied by type Mesquita (2014)

region	State	hybrid	underground	superficial	total municipality	population of the capital 2010	population of the state 2010	population of the capital 2045	population of the state 2045
north	AC	2	4	16	22	336.038	732793	614169	1315385
	AM	8	44	10	62	1.802.014	3480937	3400865	6258055
	AP	2	4	10	16	398.204	668689	817587	1369981
	PA	13	108	21	143	1.393.399	7588078	1783603	12344665
	RO	5	10	37	52	428.527	1560501	855225	2585880
	RR	5	9	1	15	290.313	451227	576351	890964
	TO	10	84	45	139	242.332	1383453	555403	2268477
	Subtotal	**45**	**263**	**140**	**449**	**4.890.827**	**15865678**	**8603204**	**27033407**
northeast	AL	11	16	75	102	932.748	3120922	1486515	4478334
	BA	32	78	307	417	2.675.656	14021432	3968174	19902901
	CE	12	64	108	184	2.452.185	8448055	3562031	12096517
	MA	11	158	43	217	1.014.837	6569683	1506584	9607401
	PB	17	34	165	223	723.515	3766834	1192187	5072801
	PE	14	17	153	185	1.537.704	8796032	2034240	12384307
	PI	8	174	40	224	814.230	3119015	1136517	4023271
	RN	3	76	85	167	803.739	3168133	1202509	9542694
	SE	8	20	47	75	579.968	2068031	991298	3207815
	Subtotal	**116**	**637**	**1023**	**1794**	**11.534.582**	**53078137**	**17080056**	**80316040**
midwest	DF	1	0	0	1	2.570.160	2562963	4607890	4607890
	GO	38	56	152	246	1.302.001	6004045	2133435	9956080
	MS	8	62	8	78	786.797	2449341	1250366	3840845
	MT	20	58	61	141	551.098	3033991	783457	4850449
	Subtotal	**67**	**176**	**221**	**466**	**5210056**	**14050340**	**8775148**	**23255264**
southest	ES	7	0	71	78	327.801	3512672	486026	5662685
	MG	171	170	512	853	2.375.151	19595309	3071507	27244128
	RJ	11	1	77	92	6.320.446	15993583	7837970	21237845
	SP	126	331	184	645	11.253.503	41252160	15237555	59986796
	Subtotal	**315**	**502**	**844**	**1668**	**9023398**	**80353724**	**26633058**	**114131454**
south	PR	89	221	86	399	1.751.907	10439601	2496422	14512549
	RS	67	286	134	496	1.409.351	10695532	1731757	13567132
	SC	58	68	165	293	421.240	6249682	726442	9779825
	Subtotal	**214**	**575**	**385**	**1188**	**358248**	**27384815**	**4954621**	**37859506**
		757	**2.153**	**2.614**	**5.565**	**31.017.111**	**190.732.694**	**66.046.086**	**282595671**

Table 2: Consequences of Impacts in the Waters of the Springs. Mesquita(2014)

activity	environmental impact	result in water quality
invasions	domestic sewage release the concentration of Al and other metals contained in the used coagulant	Eutrophication
industries	industrial sewage release	eutrophication and fish deaths
quarries	increase in turbidity	eutrophication and siltation
farming activities	increasing N, P, Si increase in turbidity	eutrophication and siltation
main ETA	the concentration of Al and other metals contained in the used coagulant	harmful to biodiversity and treatment