

Basic Sanitation in Porto Velho: the worst Brazilian Capital in this Area

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Abstract— *Basic sanitation, consisting of water supply, sanitary sewage, stormwater drainage and solid waste management, is fundamental for the quality of life of the population, reduction of public health expenditures, as well as contributing to the attraction of investments. In Brazil, the progress of these services to reach the goal of universalization is modest and Porto Velho, capital of Rondônia and located in the Brazilian Amazon, is against this advance. Its indicators show that among the 100 largest Brazilian cities in terms of population (including all capitals), its ranking of sanitation is the worst of all. This paper presents several data on sanitation in Porto Velho, comparing the evolution of its sanitation ranking and its Gross Domestic Product (GDP) ranking from 2003 to 2016, the consequences of the deficiency of these services and analyzes of current investments compared to the goals established for the universalization of sanitation in the municipality. Driven in recent years, mainly by the construction of two large hydropower plants, the population and its GDP grew, but sanitation did not follow this evolution as it should. The conclusion was that there are several problems due to the deficiency of sanitation in the city and the investments planned will not be enough to reach the goal of universalization, needing to raise more resources and prioritize the effective execution of the works contracted.*

Keywords— *sanitation, Porto Velho.*

I. INTRODUCTION

Sanitation, according to the World Health Organization [1], is the control of all factors of man's physical environment, which exert or can exert harmful effects on physical, mental and social well-being. Basic sanitation was defined by Law 11.445 [2], which establishes the basic guidelines for sanitation in Brazil, such as the set of services, infrastructures and operational facilities of: drinking water supply, sewage, urban cleaning, waste management drainage and storm water management. One of the fundamental principles of sanitation services is universalization.

Basic sanitation services are fundamental for the improvement of people's quality of life and in accordance

with the Brazilian Constitution [3], article 21, it is the responsibility of the Union to establish guidelines for urban development, including housing, basic sanitation and transport. The promotion of basic sanitation is a common competence of the Union, States and Municipalities, according to article 23. Finally, article 30, says that it is the responsibility of the Municipality to organize and provide, directly or under a concession or permit system, public services of local interest, which are essential, such as basic sanitation.

Investments in basic sanitation in cities should be one of the priorities of the public administration, aiming to provide adequate housing conditions for its inhabitants and attract more investments of industries, services and commerce. According to [4], for each US\$ 1 invested in the sanitation sector, the Brazilian economy would have an increase of US\$ 11,8 in the gross value of domestic production. Notwithstanding the fact that the economy is accounting for health expenditures due to diseases caused by lack of basic sanitation. According to the WHO, this ratio is as follows: for every US\$ 1 invested in water and sanitation, US \$ 4,3 in health costs are saved in the world [5]. A population that does not have sanitation is ill. From 20% to 30% of Brazilian households are precarious urban settlements and there are cases of waterborne diseases such as hepatitis, diarrhea, cholera, among others [6].

In Brazil, according to the latest diagnosis of water and sewage services in 2017, published by the Ministry of Cities [7], 83,5% of the population has access to a drinking water network and 52,4% of the population has network services sewage collector. Of all sewage generated, 46,0% was treated. The total investments in 2017 in the country were of US\$ 2,86 billion in water supply and sewage. In relation to GDP - Gross Domestic Product, this represents only 0,16% of the national GDP calculated at US\$ 1,74 trillion in 2017 [8].

ABRELPE - Brazilian Association of Public Cleaning and Special Waste Companies published in its latest survey of solid waste in Brazil in 2017, that the collection of municipal solid waste reached 91,2% of the total generated, which corresponds to almost 78,4 million tons.

Of this total collected, 59,1% are destined to landfills, 22,9% for controlled landfills and 18% for landfills [9].

According to the latest diagnosis of the 2017 rainwater service published by the Ministry of Cities [10], 51.8% of the municipalities have drainage systems only, and only 16.2% have urban public roads with solutions for natural drainage. In relation to rainfall drainage, [11] reported that losses due to floods in urban drainage in Brazilian cities have increased exponentially, reducing quality of life and value of properties. This process is due to the urbanization and consequent sealing together with the plumbing runoff.

The Brazilian National Sanitation Basic Plan established that the universalization of water and sewage services be accomplished by 2033. And for that, it was estimated that investments of US\$ 80 billion over 20 years would be equivalent to US\$ 4 billion per year [12].

With a current estimate of 520 thousand population [8], the municipality of Porto Velho, according to the diagnosis of water and sewage services in 2017 [7], practically did not treat its sewage, only the insignificant 1,54% of all sewage generated was treated. Only 3,39% of the sewage generated was collected by public networks. Almost all sewage goes to sinkholes or drains into streams, streams and rivers that cut through the city. Only 33,5% of the population was served with a water network [7]. Regarding solid waste collection, according to the diagnosis of solid urban waste management in 2017 [10], the waste collection rate was 98%, however, the city did not yet have a landfill for adequate disposal collected. According to the diagnosis of drainage and storm water management in 2017 [13], in the years from 2013 to 2017, 12.327 population were displaced due to floods, with 40 events occurring in 2017 and 26,1% of households were at risk of inundation. Only 18,2% of the public roads had rainwater drainage networks.

In view of this scenario, this paper aims to show how perceptible it is that instead of following the modest evolution in the development of basic sanitation in Brazil, Porto Velho is going against the grain, making it the worst capital of the country in this aspect, despite its economic growth in recent years.

II. METHODOLOGY

This work is a case study on sanitation in Porto Velho. The methodology used for the elaboration of this work was the data collection through bibliographical research on the indicators and facts related to basic sanitation in Porto Velho, besides an economic indicator of the municipality, GDP - Gross Domestic Product.

After obtaining this data, we performed:

- Analysis of the ranking of basic sanitation in comparison with that of the economic indicator;

- Description of the main problems in the basic sanitation sectors: water supply, sewage, urban drainage and solid waste;
- Analysis of the future scenario, based on the projection of the necessary investments for the universalization of the services and the current investments.

III. RESULTS E DISCUSSION

3.1. Place of study: Porto Velho

The municipality of Porto Velho, capital of the state of Rondônia and located in the Brazilian Amazon, has a population estimated at 519.531 population for the year 2019, and in 2000 the population was 334.661 population. Average geometric growth of 2,34% per year, mainly due to the construction of two large hydropower plants: Santo Antônio HPP (3.568 MW of installed capacity and cost of US\$ 6 billion) and Jirau HPP (3.750 MW of installed capacity and cost of US\$ 8 billion) started in 2008. While in Brazil, the average growth was 1,12% per year in the same period. It has an area of 34.096 Km² - the largest Brazilian capital in territorial area (more extensive than countries like Belgium and Israel). The city began in the middle of the nineteenth century, in the first movements to build a railroad that made it possible to overcome the slope of the river Madeira (about 380 Km) and give vent to the rubber produced in and in the region of Guajará-Mirim, Santo Antônio do Madeira, in the province of Mato Grosso. It was the chosen location for the construction of the port where the rubber would be transshipped to the ships, then going to Europe and the United States of America. Difficulties in the construction and operation of a river port, in front of the rocks of the Santo Antônio waterfall, made builders and ship owners use the small Amazon port located 7 Km below, in a much more favorable place, where the village began. Created by Pathfinders around 1907, during the construction of the Madeira-Mamoré Railway, it became a municipality in 1914, when it still belonged to the State of Amazonas. In 1943, it became capital and, together with the municipality of Guajará-Mirim, it became the Federal Territory of Guaporé, which in 1956 was renamed Rondônia, and was elevated to status only on January 4 of 1982 [8].

The sanitation in Porto Velho began with the construction of three water boxes (considered a postcard of the city), also called Três Marias. They were designed and built by the American company Chicago Bridge & Iron Works, in the square that is in the center of the city, which bears the same name. Its purpose was to provide water supply to the families of the construction coordinators of the Madeira-Mamoré Railway. The first water tank was erected in 1910, and the other two in 1912. The capacity of each reservoir is 200.000 liters, which until 1957

supplied the capital, functioning by gravity. No less important than the Madeira-Mamoré Railway, the construction of the three Water Boxes was a milestone in the history of engineering in Rondônia. The construction was erected based on the information contained in cast iron plate, nailed to the pilasters of each one of them. There are three cylindrical shaped tanks, covered with conical shaped metal plates, and the base in a concave shape. Each tank is raised from the ground by four iron columns made of latticework over concrete foundation. They are surrounded at the height of the bulge, by a catwalk with a metal truss of railing, with access by stairs [14].

Following, with regard to the historical context of the basic sanitation of the municipality of Porto Velho, the following facts stand out [15, 16]:

- In 1924, the city received the first water distribution network;
- In 1950, the first Plan of the city was drawn up;
- In 1972, a new Plan was drawn up called the Immediate Action Plan;
- In 1978, the Road Plan was developed with the aim of increasing accessibility throughout the city;
- In 1983, the Special Project for Medium-sized Cities was drawn up;
- In 1987, a Master Plan was drawn up, concerned with land invasions and with the objective of organizing the areas of the city in zones;
- In 1989, Main Road Plan was elaborated, where urban drainage was still considered one of the main problems;
- In 1990, a new Master Plan was drawn up, where the urban infrastructure network was still one of the precarious points of the city;
- In 2004, a review of the Master Plan was carried out;
- In 2008, the Master Plan was revised again;
- In 2009, the Municipal Sanitation Basic Plan was elaborated;
- In 2013, the City Hall promoted the I Journey for Integrated Planning, where the Basic Sanitation Plan, Macro Drainage Plan and the National Solid Waste Plan were discussed;
- In 2014, the Complementary Law was drawn up, establishing the regular and selective collection in the municipality;
- In 2015, a review of the Municipal Sanitation Basic Plan was carried out.

Currently, basic sanitation is a responsibility of the Municipal Government, which directly manages solid waste management and storm drainage services. The water supply and sewage services were transferred through a Cooperation Agreement and Program Contract to CAERD - Water and Sewage Company of Rondônia, for 30 years, according to the Ordinary Law 1.803/2009.

3.2. Ranking: sanitation x GDP

The evolution of the municipality of Porto Velho over the years 2003 to 2016 was compared through the ranking of sanitation, published annually by the Instituto Trata Brasil, and the GDP (Gross Domestic Product) ranking published by IBGE - Instituto Brazilian Geography and Statistics, as shown in Fig. 01.

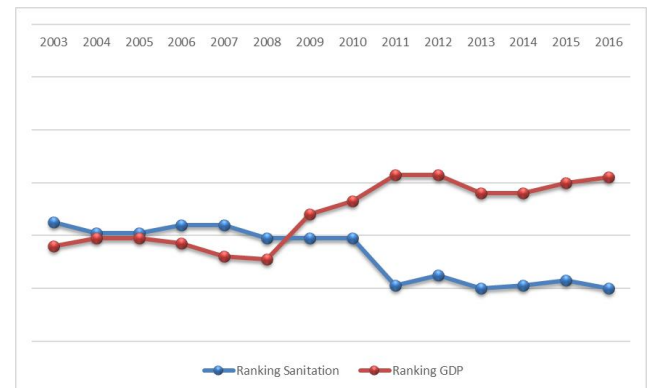


Fig. 1: Ranking Sanitation x Ranking GDP - Porto Velho.

It was observed that the GDP ranking improved over time, mainly from 2008 (coinciding with the start date of the construction of the two hydroelectric plants on the Madeira River), showing an economic growth of the municipality, while the sanitation ranking was contrary to this tendency, worsening over time, especially in 2010, where there was a significant increase in population due to the fact that the construction of hydroelectric dams and infrastructure for water supply and sewage remained practically the same since the 1970s.

What was expected would be just the opposite: the better the ranking of GDP, the better the ranking should be in sanitation, since if the municipality was improving its ranking in GDP - consequently it was in better financial condition and could invest in sanitation, improving its ranking in sanitation, which did not happen.

3.3. Water supply

The main problem of water supply is the shortage of service to the population of this service, with almost 400 thousand inhabitants without access to drinking water by public network. The consequence is the drilling of thousands of private wells to supply the buildings. However, according to the study [17], the aquifer Jaciparaná, which is located under the city and was widely exploited by the local population for water supply, was already contaminated by sinks constructed with an average depth of 2 meters. disposal of domestic waste, a reflection of the lack of sewage collection networks.

Another study of [18] on a spatial assessment of groundwater quality in the urban area of Porto Velho concluded that the water from the water table of the wells drilled in the city had high levels of bacteriological contamination, indicating the presence of fecal coliforms

and of total coliforms, that is, unfit for human consumption and in some cases even for other uses.

3.4. Sanitary sewage

The main problem is the lack of sewage collection service. This fact has two serious consequences: (a) drilling of sinks for the disposal of sewage generated in buildings, which contaminate groundwater, mainly with coliforms - as mentioned previously; (b) several places with sewage running in the open, contaminating the urban streams and proliferating diseases, especially with the occurrence of floods.

To illustrate this proliferation of diseases, a study published by [19] on the relationship between lack of sanitation and the occurrence of diarrhea, dengue and leptospirosis, showed that, in the period from 2007 to 2015, the 10 worst cities in the sanitation ranking (among them Porto Velho) had about 4,06 times more hospitalizations of diarrhea than the 10 best cities; 4.04 times more dengue hospitalizations; and 5,3 times more hospitalizations of leptospirosis.

The igarapés, which for 30 years were places of leisure, are now pollution points. Although it did not have a study that verifies the pollution of the seven igarapés of the city, a significant amount of rubbish and rubble thrown in its 40 kilometers was verified. This situation worsens during the drought. The adverse effects are most evident in the dry season, when the natural water flow is very small and insufficient to dilute the waste and waste that were improperly disposed of, according to a study carried out by the Amazon Protection System [20].

3.5. Urban Drainage

There are several studies that show that there are several areas at risk of flooding in the city, and are even repeatedly mentioned in the master plans elaborated. The city is located at an average altitude of 85m in the valley of the Madeira River between the Amazonian plain and the Brazilian central plateau. Therefore, the city does not have large variations of relief, which makes difficult the construction of urban drainage, being necessary the construction of deep galleries to allow the flow. The solution, so far, has been the use of the urban igarapés as macro drainage of the city [16]. However, the urban occupation on the banks of these igarapés were reducing their gutter, in addition to the contamination factors for the discharge of sewage and solid waste, according to the studies presented below.

According to a study carried out by [21] on the classification of risk in areas subject to flooding in the urban basins of the Big and Santa Bárbara streams, the annual recurrence precipitation presented intensity of 48 mm / h, with a precipitation of less than 14 mm / h is sufficient to cause flooding. This rainfall intensity is exceeded by 10% of the events recorded each year. In addition, three critical points were identified, which

presented rainwater impoundment, requiring intervention with engineering works, that is, scaling of the respective manholes.

In the study developed by [22], on the areas with potential flooding in part of the surroundings of the city of Porto Velho, the author reported in his conclusion that they occurred with the intensification of anthropic actions in potentially floodable places, soon unsuitable for housing and reinforced the importance of adopting properly planned and implemented territorial planning policies for sustainable development, thus seeking to avoid irreversible effects over time.

Another study, carried out by the Amazon Protection System (SIPAM) in partnership with the City Hall, showed that the capital of Rondônia has 16 areas at risk of flooding. The objective was to identify flood-prone areas and help the public authorities to plan strategic actions at these sites. Of the 27 points analyzed, 16 were subject to a rise in water level. Based on the scientific knowledge of these areas and the periodicity of the floods, the city may take structural measures, such as the expansion of manholes and bottlenecks in the streams. In the long term, the product can also be applied in the design of areas of APPs - Environmental Protection Areas - urban and urban land use planning [20].

According to the Flood Vulnerability Atlas [23], in Porto Velho, along the Madeira River, 37 flood areas were identified, of which 20 are highly vulnerable, which means a high risk of damage to human life and significant damage to essential services, public and residential infrastructure and facilities. In this sense, it is worth noting the recorded flood of the Rio Madeira in 2014. Considered the largest of them, Rio's maximum quota reached 19,69m (the historical peak previously recorded was 17,44m), and the quotas provided by the agencies competent, before this flood, were: 15,00 m for the attention quota, 16,00 m for the alert quota and 17.00 m for the flood quota. The maximum flow rate was 58.920 m³/s (the historical maximum flow registered previously was 48,565 m³/s), being more than 63 days with flows above 50,000 m³/s. In this flood of 2014, more than 100 thousand families were reached and more than US\$ 1,3 billion needed to heal the damages caused [24]. According to a report issued by the Federal Comptroller General's Office [25] on the situational diagnosis of the Madeira River flood in Porto Velho, the extent of the damage and the application of the resources made available by the Federal Government to assess the areas affected by the flood, totaling a volume of US\$ 1,7 billion.

3.6. Solid waste

The construction of a municipal landfill has been postponed and the estimated initial investment in 2014 was US\$ 14,6 million for the construction of the Waste

Treatment Center, which includes landfill, sorting center, composting plant and construction industry [16].

The selective collection serves only 25.74% of the population. There is an association of collectors of recyclable materials and more diverse collectors who do not belong to it. The recovery rate of recyclables compared to the generated waste is only 0,86% and the volume of 4,26 kg per inhabitant per year [10], while in Brazil the average recycling was 13% of waste generated [26].

Regarding the solid waste of the civil construction, the city hall does not have a suitable place for the destination of the same ones. Recently, held the First Symposium on construction waste whose purpose was to clarify that the City was regulating the management of this waste. There was only one company that did this recycling service and the city hall wanted to prepare the construction sector so that it could actually manage its waste [16]. According to [27], in Brazil, 90% of the waste generated by the works is recyclable and taking into account its continuous generation, the recycling of Civil Construction Waste is of fundamental environmental and financial importance in the sense of that the said residues return to the work in substitution for new raw materials that would be extracted from the environment. It is an activity that must be carried out in the very first place, but which can also be carried out outside it.

The management of the waste from the health services, from the collection to the final adequate disposal, is under the responsibility of its generators who must prepare the Health Services Waste Management Plan, as determined by Complementary Law 136/2001. For waste generated in public establishments, the city has an incinerator to carry out the appropriate disposal of the same.

Hazardous waste follows the requirements of Complementary Law 138/2001, which established the municipal environmental code, and its generators are responsible for everything from collecting, transporting to final destination. There are specialized companies in the city that carry out the collection of this waste and transport it to appropriate and legalized landfills in other states.

3.7. Future scenarios for basic sanitation in Porto Velho

The goals established in the PLANSAB - National Plan for Basic Sanitation [28], for the North region or specific for the state of Rondônia, are shown in Table 01.

Table.1. Basic sanitation goals for Rondônia or North region.

Year	Water supply*	Collect sewage*	Treatment sewage	Collects waste*	Select Collections	Floods
2010	84%	22%	62%	89%	5%	33%
2018	90%	47%	75%	93%	12%	--
2023	94%	63%	81%	96%	15%	--
2033	100%	94%	94%	100%	22%	6%

* Specific target for Rondônia.

Source: PLANSAB - National Plan for Basic Sanitation [28].

According to the study carried out by the PMSS - Program for the Modernization of the Sanitation Sector specifically for the planning of water supply and sewage services in the state of Rondônia [29], referring to CAERD - Water and Sewage Company of Rondônia, which has the Porto Velho water and sewage services concession, the executive summary concluded that CAERD is in a vulnerable financial situation, requiring action on several fronts, requiring several strategic actions, among: (a) commercial policy focused on collection and search of customers with low implementation costs; (b) financial negotiation of the high indebtedness observed, which has a high degree of articulation with the governmental spheres; (c) increase, in a short period of time, the productivity of the main factors and production inputs - electricity, chemicals and personnel, with the purpose of reducing operating costs; (d) prioritize investments, at a first stage, with a high cost-benefit ratio, in order to generate the bases for a self-sustaining financial expansion; (e) combating delinquency, since the accumulation of uncollected and unpaid bills has been high.

With these shortcomings presented by the CAERD, one of the consequences for the municipality of Porto Velho was the absorption of the costs of other municipalities' systems and, thus, presenting low performance indicators, as reported in the conclusion of the aforementioned PMSS study.

In the study of [30] on the economic benefits of the expansion of sanitation in Rondônia, the investment necessary in 30 years for the universalization of water and sewage services throughout the state was US\$ 940 million, equivalent to 12,7 % of GDP in the state of Rondônia. According to the study's estimate, with the universalization of sanitation in Rondônia, there would be a total gain of US\$ 2,29 billion over 30 years, considering

as a consequence of the universalization: (1) gain with reduction of hospitalization costs; (2) reduction of loss of work; (3) increase in productivity at work - current generation and the new generation; (4) real estate valuation; (5) tourism. The final balance, considering the gains (US\$ 2,29 billion) minus the investment (US\$ 947 million), would be a positive balance of US\$ 1,34 billion over the 30 years considered.

In order to universalize all basic sanitation services in Brazil (water, sewage, waste and drainage) would require US\$ 133,7 billion from 2014 to 2033, according to PLANSAB - National Plan of Basic Sanitation [28].

Due to the lack of more in-depth studies on the real need for investments in Porto Velho for the universalization of basic sanitation, a simplified estimate was made: the per capita cost for Brazil was calculated (total investments / current population), reaching a value of US\$ 631/inhabitant. Considering the current population, it is estimated a total value of US\$ 329 million necessary for the universalization of basic sanitation services (water, sewage, waste and drainage).

Investments in water and sewage services in the city depend on external resources, since CAERD does not have the financial capacity to contribute them. Consulting the available data on PAC's website - Growth Acceleration Program (PAC in Portuguese), the federal government identified 10 projects that received funding from the PAC in Porto Velho to improve basic sanitation in the municipality, totaling US\$ 204,2 million, excluding there were 2 projects that did not have their values divulged due to the possibility of using the Differential Contracting System [31]. Summed up the investment disclosed for the construction of the landfill, initially estimated at US\$ 14,6 million [16]. However, many of these works were started and not completed.

Therefore, investments made in basic sanitation for Porto Velho totaled US\$ 218,8 million in recent years, but many of them with unfinished works, which corresponds to approximately 66% of the investment calculated to universalize basic sanitation services.

The indicator of investment in Porto Velho was only US\$ 1,57 per inhabitant in 2017, the lowest of all Brazilian capitals. While in Brazil, the total investment in the last 13 years was equivalent to US\$ 16,00 per inhabitant per year [32]. That is, an investment equivalent to only 9,8% of the average Brazilian value.

IV. CONCLUSIONS

Independently of the plans elaborated on the basic plan for the city of Porto Velho; despite the population growth in the last 19 years, above the Brazilian average; despite economic growth, GDP results in recent years - a proportional growth at least double that of the new city of the country; basic progress index in Porto Velho and in

the comparison of the GDP ranking, since, in comparison with the ranking of GDP improved and ranking of sanitation worsened.

Growth water indicators have declined over time - due to lack of investment and population growth; and yet since the mid-1970s the water supply network was practically the same - concentrating on the center of the capital. With regard to sanitary treatment, the extraction of water, water and water contaminate the average levels of water in the form of contaminated water. The urban drainage deficiency generates an urban pollution, and yet, there are several points of flood in the city, spreading waterborne diseases. The selective collection was done inappropriately, the selective collection was completed only 1/4 of the population and only 0,86% of the waste generated.

Considering the goals of universal sanitation established by PLANSAB - National Plan of Basic Sanitation, if there is no change of course and priorities, in addition to a strong investment action in the sector, the trend will be that the capital will not reach these goals until 2033. The current investments, if actually applied, will minimize the situation, but will not be sufficient to remove it from this serious situation in relation to basic sanitation, since they are equivalent to approximately 2/3 of the estimated investments required for universalization of the services in the capital of Rondônia, still missing the capture of 1/3 of the investments.

And finally, investing in basic sanitation reflects on the improvement of the quality of life of the population and economic gains for the municipality, as has already demonstrated numerous studies on the subject. Porto Velho, in the last decades, has always been against this strategic action. It is now time to change the course to eliminate the deficit generated, together with the new future demands with adequate technical solutions and effective actions within the deadlines established in the goals.

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