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Extension of the water distribution network in subnormal regions in the Manaus city

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***Abstract*—** *Due to the enormous socioeconomic inequality that marks the history of Brazil, the low-income population without government support uses irregular, disordered and precarious alternatives to structure their homes. Irregular land occupations are among the main types of construction in this regard and have raised numerous discussions on issues such as income concentration, land reform and land redistribution for decades. The so-called stilt houses also stand out in areas with rivers and lakes of great extension, with high rates of rainfall and flood.*

In these places, minimum sewage system is irregular and improvised, with pipelines that are so short that they do not even touch the river, that is, the sewage falls in cascade mixing to the waters. In river flood time, the river level rises and such dirty water invades the stilt houses, when residents start to live daily with raw sewage directly on the floor of their homes, exposed to bad smell and disease-causing agents. This problem also ends up compromising the sanitation of the entire city because during intermittent periods, clandestine connections end up sucking the water from rivers due to pressure and again polluting treated water distributed by regular supply.

In these places clandestine connections must be changed for regular water distribution networks treated on the stilt houses.

***Resumo*—** *Em virtude da enorme desigualdade socioeconômica que marca a história do Brasil, a população de baixa renda e sem suporte governamental recorre a alternativas irregulares, desordenadas e precárias para estruturarem suas residências. As ocupações irregulares de terra estão entre os principais tipos para construção nesse sentido e levantam inúmeras discussões a respeito de temas como concentração de renda, reforma agrária e redistribuição de terras há décadas. As chamadas palafitas também se destacam em áreas com rios e lagos de grande extensão, com altos índices pluviométricos e alagadiça.*

Nesses locais, a mínima rede de saneamento é irregular e improvisada, com tubos tão curtos que nem sequer chegam a tocar o rio, ou seja, os dejetos caem em cascata e se misturam às águas. Nas cheias, o nível sobe e toda essa água invade as palafitas, quando os moradores passam a conviver diariamente com esgoto in natura diretamente no chão de casa, expostos ao mau cheiro e a agentes causadores de doenças. Esse problema também acaba comprometendo o saneamento de todo o município, já que, nos períodos de intermitência, as ligações clandestinas acabam sugando as águas dos rios devido à pressão e poluem novamente a água tratada e distribuída pelo abastecimento regular.

Nesses locais devem ser trocados as ligações clandestinas por redes regulares de distribuição de água tratada nessas palafitas.

***Palavras-chave*—Abastecimento, Água, Desigualdade, Saneamento, Palafita.**

I. INTRODUCTION

1.1SANITATION IN BRAZIL The first well was drilled in 1561, to supply the city of Rio de Janeiro headed by Estácio de Sá. where the first happened, we can register as the introduction of Sanitation in Brazil [1].

Several factors over the years have hampered the progress of sanitation in the country. The lack of management of the sanitation companies, and projects with low technical quality, added to the difficulties in financing and obtaining concessions for the execution of works. Some of these until today is the impediment in the country hindering the development of the area lagging behind the countries of the world.

1.2 LAWS OF LEGISLATION Over the years, several problems have arisen and with an impact of minimizing their impacts, guidelines have been created in Brazil, implementing media and infrastructure.

The National Sanitation Plan was formed in the 1970s, PLANASA.At the beginning of 2007, after Federal Law 11,445 was enacted, municipalities became responsible for sanitation. In the same year, the National Basic Sanitation Law came into force, already establishing national guidelines.

Currently, there are bodies responsible for conducting and politically guiding public policies. The instrument that guides the conduct of public policies, goals and policies for the sanitation sector is the PLANSAB (National Basic Sanitation Plan). There are agencies that are responsible for monitoring these laws and guidelines, where we can mention the National Water Agency, which is responsible for the management of water resources, the National Sanitation Information System (SNIS), is the largest information system on sanitation in Brazil.

Currently, we have 83.7% of the Brazilian population served with treated water and 37% of the water treated by the concessionaires is not consumed according to information from the National Sanitation Information System.

Due to the enormous socioeconomic inequality that marks the history of Brazil, the low-income population without government support uses irregular, disorderly and precarious alternatives to structure their homes. Irregular occupations are among the main types of construction in this regard and have raised numerous discussions on topics such as concentration of income, land reform and land redistribution for decades. The solution for some families is the construction of their properties in swampy areas or on rivers, the so-called stilts (“Fig. 1”).

Fig. 1: Imagem de moradias chamadas de Palafitas

To get an idea of the scale of the problem, the Brazilian Institute of Geography and Statistics (IBGE) estimated that, in 2010, 11.4 million people lived in such regions, named as subnormal agglomerations. The data is the most updated to date, since the operation for its survey is carried out only every ten years.

Under these conditions, the people who live there suffer from the lack of guaranteed rights and basic resources, such as access to quality food, health, electricity and, of course, sanitation. This indicator, in particular, compromises mainly the quality of life in the North and Northeast regions, which, respectively, remain with 43.5% and 26.1% of their homes without access to the water supply network, according to the National Survey by 2015 Household Sample, prepared by the same institute.

1.3 STILT HOUSE In the 50's there was an urban growth in the center of the city, where a population originating in the interior of the State that was forming clusters of small areas forming a kind of floating neighborhood. This place was located close to the Feira da Manaus Moderna, where restaurants, butchers, workshops and others operated, forming a floating city. This city was constantly in the news both nationally and internationally, being the subject of some national magazines of the time.

In 1966 the city was "undone", the neighborhood was made up of approximately 1,950 houses. At the time, there were about 1,950 houses that made up the neighborhood with an average of 11,500 residents.

Even though the floating city has been extinct for more than 5 decades, the culture of building wooden

houses bordering rivers and streams continues in the city of Manaus. Unlike other decades, houses are no longer floating [2].

1.4 THE FLOODS Year after year, the Rio Negro invades part of the city, with the population from Manaus facing floods, which until now the only solution found is to make wooden bridges so that pedestrians can move from their homes to the destination if you have to leave your homes. This abundant water is related to the La Niña phenomenon, which acts in the summer and in the autumn, with a greater than normal stimulus of rain over the Amazon basin. The flood occurs due to the excess of rain in summer and autumn in the Southern Hemisphere and also by the melting of the Andes [3].

Data from base year 2021, the National Information System, 98% of the population of Manaus has a supply of drinking water, rising 7 positions in the ranking of the 100 largest cities in the country compared to the previous year, as a result of investments in sanitation in a short time. operation in the city by the Sanitation Company of the AEGEA Group [4].

II. METHODOLOGY

The methodology of this article is divided into distinct and specific stages. The article was based on a bibliographic review of current legislation, technical standards and specific local solutions, linked to criteria for the elaboration of drinking water supply network projects.

The entire historical context found in books, articles and magazines was taken into account, emphasizing the importance of consuming treated water for disease prevention and as an essential good for human life.

Therefore, the research is classified as exploratory, investigating and taking notes of what would be necessary in order to implement the supply project in a stilt region, a vulnerable region found in the South Zone of the city of Manaus, the same is descriptive, where it will be evidenced clearly the conditions of the study site, it is also quantitative with regard to the number of inhabitants benefited with the supply of drinking water and water volume that the sanitation company has not measured for more than 10 years.

Finally, it is a case study that addresses the importance of supplying treated water to subnormal regions with photographic surveys.

In floods, the level rises and all this water invades these houses ("Fig.2"), when the residents start to live daily with fresh sewage directly on the floor of the house, exposed to bad smells and disease-causing agents.

In these places clandestine connections must be exchanged for regular water distribution networks treated on these stilts.

Fig. 2: Stilts being invaded by the Rio Negro flood

Considering the scenario and the urgency of the service, the option is for the installation of modern airways, which enable delivery of the same efficiency as the traditional ones and do not require drilling and excavation works, which are not feasible in the terrain in question ("Fig.3").

Fig. 3: Aerial water supply network on stilts

2.1 LOCATION In this context that Manaus is experiencing, in the light of sanitation, this study proposes a water supply solution in a region of stilts in the Cachoeirinha neighborhood (BecoNonato), South Zone of the city of Manaus ("Fig.4") and points out the benefits of implementing a water supply project as a solution for the distribution of this essential good, which is treated water.

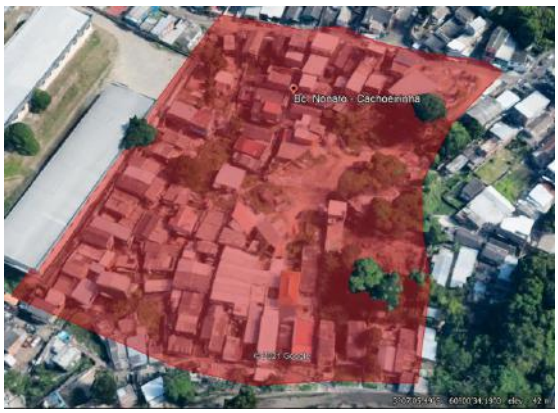

Fig. 4: source: Google - BecoNonato, Cachoeirinha, Manaus

2.2 SUPPLY CONDITIONS In these places, the minimum water supply network is irregular and improvised, with adapted pipes and connections, with a great possibility of contact with the wastes that mix in the water in which the houses are built because they do not also have the structure of sanitary sewage in addition to contact with venomous animals found in the region because of the garbage found nearby.

2.3 HYDRAULIC MODELING After collecting the data, they go to the project sector to perform hydraulic modeling using the QGIS Softwares, a professional GIS Free and Open Source application, which is built from Free and Open Source Software, (FOSS), WaterGems is a complete and easy-to-use tool that assists in making decisions about water distribution networks [5]. Through it, simulations of the behavior of the hydraulic system of the region are carried out, finalizing the project in the AutoCad software [6].

The material of the pipes used for the execution of the water supply network was made of high density polyethylene (HDPE, or in English, HDPE), it can be used in drinking water lines, waste water, sludge, chemicals, hazardous waste and compressed gas according to NBR 15561: 2017.This type of pipe can be cited several advantages in its use, which are: Great resistance to corrosive agents, low friction loss, thanks to its smooth walls, low encrustation effect and low weight, which facilitates its handling and installation, in addition to being able to use to carry out the aerial installation ("Fig.6"), reason for this study, because the polyethylene tubes are produced with the addition of 2 to 3% by mass of finely dispersed carbon black, presenting an excellent resistance to UV rays, with low loss of characteristics over its useful life, considerably over 50 years, according to the project specifications [7].

The support points, ideally, the pipe should be installed such that it does not suffer additional efforts to the internal pressure, allowing it to expand or contract freely, bending or flexing without causing efforts on its supports ("Fig.5") , nor suffer the consequent efforts, such as bending moments, buckling, traction, etc., which could compromise its useful life. For this, it was used the orientation chart ("Fig.4") provided in the Manual of Good Practices by ABPE, Brazilian Association of Polyolefinic Tubes and System, where, in the abscissa, the outer diameter of the tube (mm) and the ordinate, the maximum distance (cm) between the supports that will support the water pipe filled with water according to its temperature.

2.4 MEASUREMENT SYSTEM Measuring systems in the water supply are indispensable instruments for the effective operation of public systems [8].

The measurement of water consumption at each point of the water supply system, the so-called micro-measurement, where it allows recording the volume of water used by the consumer unit. The installation of these measuring devices (hydrometers), contributes to the care of the environment, as it leads to a reduction in the waste of water by the consumer.

After the installation of the network, we made the water connections, using in the building extensions the same material used in the supply networks, HDPE, installing a meter (water meter) for each residence, thus having an individual measurement.

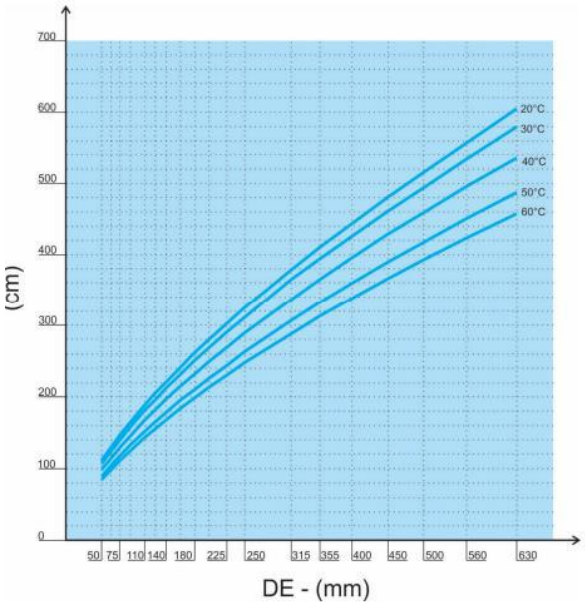

Fig. 4: Guidance chart, about distance between supports for tubes filled with water.

2.5 WATER LOSSES IN SUPPLY SYSTEM Characterized as lack of technical efficiency, the losses are inseparable from any water supply system. It is a subject of great value in the face of water shortages and high electricity costs, in addition to its direct relationship with the financial health of the Supply Companies of a city, since they can be considered as waste of natural resources and loss of revenue.

Actual losses are defined in all treated water offered for distribution that does not reach the consumer's meter. These losses result from leaks in pipelines, networks, branches, connections, reservoirs, in addition to frauds made with low quality material and connected in any way.

In these areas, as they still did not have a projected supply network, the residents as a means of survival, interconnected in a clandestine manner and in any case, often contaminating the water of their own consumption and the city's supply system.

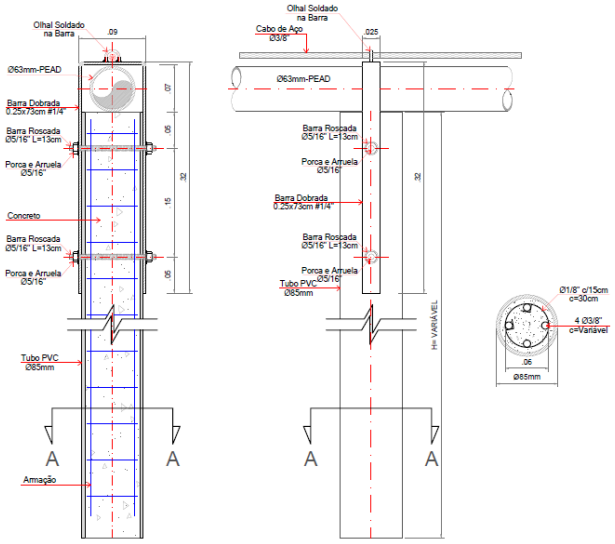

Fig. 5: Detailing of support supports.

Fig. 6: Aerial Supply Network made with HDPE tube.

2.6COMMERCIAL SYSTEM REGISTRATION With the cadastral survey and project completed, customers in the region are registered in the commercial system (GSS) of the Companhia de Saneamento responsible for the city's water supply.

III. STANDARDS

ABNT (Brazilian Association of Technical Standards) standards, which are based on international standards, are used to standardize the presentation of scientific papers across the country in order to facilitate the reading and understanding of the thousands of researches carried out every year [8]. The rules used for this project were:

3.1 NBR12266 –Design and Execution of Ditches for the Laying of Water, Sewer or Urban Drainage Pipelines - This Standard sets out the conditions required for the design and execution of ditches for the laying of water, sewage or urban drainage pipes. It also establishes criteria for positioning the ditch on the public road and dimensioning the shoring [9].

3.2 NBR 5626 NB 92Cold Water Building Installation - This Standard establishes requirements and recommendations regarding the design, execution and maintenance of the cold water building installation. The requirements and recommendations established here emanate fundamentally from respect for the principles of good performance [9].

3.3 NBR 15561:2017Polyethylene piping PE 80 and PE 100 for transporting water and sewage under pressure - This Standard specifies the requirements and test methods for manufacturing and receiving polyethylene tubes for transporting fluids at temperatures up to 40 ° C, with maximum pressure of operation of up to 2.5 MPa, designed for a useful life of 50 years, intended for use in: a) building water branches; b) water distribution networks and pipelines; c) pressure sanitary sewer lines [9].

IV. RESULTS OBTAINED

With the 507m laden drinking water distribution system, 105 properties were supplied with their individual meters (water meters) installed ("Fig.7"), with an estimated population of 635 beneficiaries. The measured volume of this area in the last 12 months of the system's activity, was more than 21,000m³ of water ("Fig.8"). A monthly average of 1,600m³ and 15.45m³ per property.

Fig. 7:Medidores (hidrômetros) instalados em palafitas

4.1 GROWTH OF COVERAGE With the installation of the water supply network in operation, the Concessionaire in the region is sure that it is bringing health to more people, with this there is an increase in coverage in the distribution of treated water to the population.

4.2 SOCIAL With customers registered with Supply Company, they now have proof of residence, meaning of dignity, where they can prove their residence when looking for a job, enrollment in schools, installment plans in local businesses, bank account, among others.

4.3 QUALITY OF LIFE AND HEALTH Once these residents of these regions are supplied with drinking water, they no longer need to boil their water before making food or even drinking.

4.4 LOSS REDUCTION As soon as it is able to measure the consumption of each residence, the supply company starts to reduce its losses, since at that moment it is able to measure what it has not been able to do for years due to clandestine connections and leaks in the adapted connections.

4.5 MAINTENANCE With overhead networks, if there is any type of leak, detection and maintenance is much faster than an underground leak.

4.6 SOCIAL TARIFF Residents in these regions have benefited from the Social Tariff, a benefit established by the Municipal Decree, which grants a discount on the water bill to low-income residents.

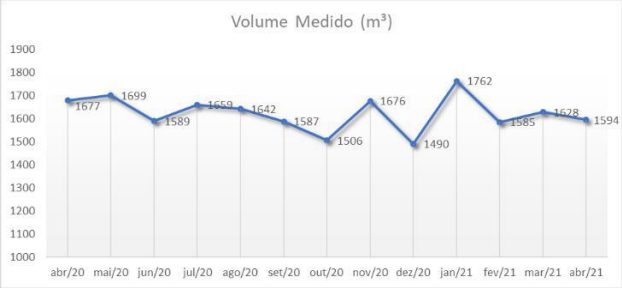

Fig. 8: Volume measured in the last 12 months (Source: Águas de Manaus)[13]

To prevent the meters from being submerged during the flood season, they were placed at a height above the region's historic flood height (“Fig 9”). Through an initiative of the Company, all these families had a different tariff charge and, in addition, managed to give dignity to those people who previously did not want to, a proof of housing and today they can be proud to say that they can prove where they live.

4.7 ECONOMIC - Before installing the supply system on site, residents compare gallons of mineral water to drink, sometimes even to cook with the cost of a gallon with 20l of water in the city of Manaus, ranging between 5 and 7 reais. Taking into account the average of 4.07 inhabitants in a domicile occupied in subnormal agglomerates [10], ingesting an average of 2l of water / day, as instructed by the Ministry of Health [11], the monthly consumption of gallons would revolve around 12.2 gallons, totaling a monthly cost of gallon water of around R $ 73, when the social tariff for each 1,000 l of water comes out at R $ 1,993 according to the city's Water and Sewage Concessionaire website [12], equivalent to 50 gallons of water of 20 liters.

V. CONCLUSION

These actions make a larger amount of water available to the supply system, since there is a substantial reduction in distribution losses, promoting dignity, quality of life, public health and the protection of the environment for any and all citizens.

With the new Basic Sanitation Framework signed in July 2020, Law No. 14,026 [14] will be the “North” for the advancement of water distribution in these regions, where the Federal Government's goal is the universalization of Sanitation by 2033, and with this will have major investors in basic sanitation in Brazil.

Fig. 9: Resident receiving treated water under his tap

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