Drinking Water Distribution in the Urban Area of Paraná: Implementation of Flow Sensors

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Abstract— **This paper focuses on the water outages that permanently take place in the city of Paraná, a city in the Entre Ríos Province, Argentina. This problem is caused by the lack of advanced infrastructure and the high water consumption in this city. This project aims to reduce water outages in the urban part of the city by introducing water flow sensors as a way to address the problem. In order to achieve this aim this work first analyses the problem in terms of the context, the main issue, as well as the causes and consequences. After this, the implementation of water flow sensors is introduced. Finally, the strengths and weaknesses of the proposal are presented. It is expected that this paper may raise awareness about the importance of technological solutions to improve water resource management.**

Keywords: **water outages, water flow sensors, drinking water distribution.**

Resumen— **Este trabajo se centra en los cortes de agua que de manera permanente se presentan en la ciudad de Paraná, ciudad de la Provincia de Entre Ríos, Argentina. Este problema es causado por la falta de infraestructura avanzada y el alto consumo de agua en esta ciudad. Este proyecto apunta a reducir los cortes de agua en la parte urbana de la ciudad mediante la introducción de sensores de flujo de agua como una forma de abordar el problema. Para lograr este objetivo, este trabajo primero analiza el problema en términos del contexto, el problema principal, así como las causas y consecuencias. Posteriormente se introduce la implementación de sensores de flujo de agua. Finalmente, se presentan las fortalezas y debilidades de la propuesta. Se espera que este trabajo pueda generar conciencia sobre la importancia de las soluciones tecnológicas para mejorar la gestión de los recursos hídricos.**

***Palabras clave*: cortes de agua, sensores de flujo de agua, distribución del agua potable.**

I. Introduction

The city of Paraná is a large city and it is the capital of the province of Entre Ríos, Argentina. This city is located in the west of the province (Fig. 1). Its area is 4,974 square kilometers and it has a population of about 391,962 people, according to the last census in the year 2022 [1].

Consequently, the large population that lives in this city leads to several problems derived from lack of proper urban planning to face this increasing growth. Among these problems are the water outages in the urban area of the city. This work focuses on this area due to the frequency of water outages in this place.

This project is in line with the United Nations' Sustainable Development Goal (SDG) #6. SDG #6 aims to ensure availability and sustainable management of water and sanitation for all [2]. However, challenges remain in its implementation at the local level. In Paraná, drinking water is not available for every resident. There are 141,269 homes, of which 134,525 have access to running water. This represents approximately one home every three people.

Bearing these notions in mind, the purpose of this paper is to analyze the implementation of flow sensors in the drinking water distribution network in the urban area of Paraná so that all the homes can have water at all times. In order to achieve this aim, this paper is organized as follows. Firstly, this paper is going to show the geographical area that is the focus of this work. Secondly, this paper is going to discuss the issues connected with the current water distribution system in this region. Next, the factors that give rise to these issues are going to be introduced, namely, the lack of real-time monitoring and undetected leaks. After this, this paper is going to discuss the impact that these inefficiencies have on the water supply and service quality. Finally, this paper is going to describe an action plan to approach this problem by means of implementation of flow sensors, highlighting the strengths and weaknesses of the proposal. It is expected that this paper may raise awareness about the importance of technological solutions to improve water resource management.

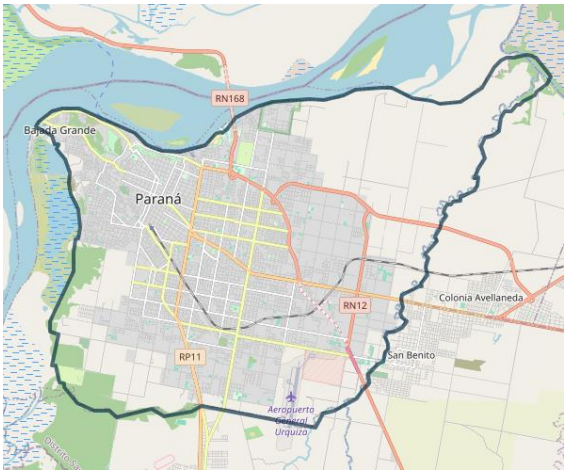

Fig. 1. Paraná city map [3]

II. Problem Description: Water Outages in the Urban Area of Paraná

Paraná is a city with a large population, which leads to high water consumption. This city is limited by a river, which is called the Paraná River, and 232 million liters of water are extracted from it daily for human consumption [4].

This project is going to focus on the urban area of the city. In this area, there are more water outages because water needs more pressure to reach this area, which causes pipes to break.

To better frame this problem, the spatial inequality of domestic water consumption has been examined in a previous research paper [5]. It was found that higher-income households consume significantly more and receive more subsidies than lower-income households. From this perspective, a broader understanding of how inequalities in water access may emerge in large urban areas can be obtained.

A. Water outages in the urban areas of Paraná

Water outages are a recurring problem in the urban areas of Paraná. The city's water distribution system suffers frequent pipe breaks, leaving many households without supply. To overcome this, some families resort to installing water storage tanks in their homes.

Excessive water consumption further aggravates the situation. Although the World Health Organization recommends less than 100 liters per person daily for drinking, cooking, personal hygiene and home cleaning, actual consumption can reach up to 500 liters per person [6]. Frequent interruptions in the city's water supply are caused by a combination of high water consumption and an aging distribution network, as it is described in the following sections.

B. Identification and Analysis of Causes or Factors that Give Rise to the Problem of Water Outages

Water outages in Paraná can be caused by several factors. Firstly, one of the main reasons is infrastructure failure, because of old and deteriorated pipes and water treatment equipment [7]. Over time these systems can become damaged and cause interruptions in the continuous supply of water.

Secondly, the water supply system can be overloaded during peak consumption periods such as the summer months or population peaks due to increased demand, as [8] states. This situation is aggravated when leaks in the pipe network are not detected, which causes low water pressure.

Third, technical failures in water treatment plants play an important role in water outages. These plants are responsible for processing and supplying clean water to the population. However, if the equipment does not function well, or if the plants are overloaded with demand, they may not be able to supply sufficient treated water, resulting in service interruptions.

Extreme weather conditions are another cause that can be highlighted. For example, the supply of water in storage tanks can be reduced by prolonged droughts, while infrastructure can be damaged by torrential rains, causing floods that affect the water distribution network, as analyzed in [9].

Finally, lack of investments to improve the water system make these problems even worse. When planning is bad, repairs are delayed or financing for modernization is insufficient, the system is more vulnerable to outages. Good management and proactive investments are essential to help keep the water supply safe and secure.

C. Identification and Description of the Consequences of Water Outages

There are many consequences of water outages. Firstly, one of the consequences of water outages is that they can affect public health. Without clean water, people are more at risk of getting sick because of lack of hygiene [10]. Everyday tasks such as cooking, cleaning and washing are made difficult, and the quality of life for everyone is consequently reduced.

Secondly, the interruption of water supply has an economic impact. Businesses that need water, such as restaurants, hotels and factories, cannot function at full capacity, resulting in loss of money and productivity. Some have to close temporarily, which can cause people to lose their jobs [11].

Third, one of the consequences is the lack of lessons at schools and universities due to water outages. This affects student learning, which is complicated in areas where education is a big challenge.

Water outages also increase social inequalities. Poor communities, which do not have access to other water sources, are the most affected ones. They may not be able to buy bottled water or other options, which makes their situation more difficult. The environment can also be affected. When people use water sources, such as rivers, it can reduce the quantity of water available in the future. When water returns after an outage, the pressure can also damage old pipes, causing leaks and wasting more water.

Finally, frequent water interruptions can cause discomfort among people. Without good management and proactive investments to resolve the problems, which can cause protests, as stated in [12].

III. Implementation of Water Flow Sensors to Detect Leaks and Failures

The solution to the problem focuses on the implementation of flow sensors to improve water distribution in the urban area of Paraná. The steps to be followed are detailed below.

A. Description of Implementation of Water Flow Sensors

A flow sensor is a device that works by measuring the velocity of the liquid in the pipe with external transducers. For the water distribution system are selected, considering factors such as precision, durability, and cost. The sensors will be installed at strategic points in the water distribution network.

There are different water flow sensors, and they must be able to measure the water flow rate with precision and send data in real time to a control center. The Clamp-on Ultrasonic Flowmeter (Fig. 2) uses transit time technology to measure the flow of liquids without direct contact with water.

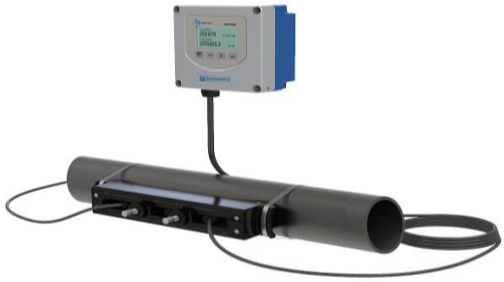

Fig. 2. Clamp-on Ultrasonic Flowmeter [13]

This sensor works by measuring the velocity of the liquid in the pipe with external transducers. These send out ultrasonic signals that move faster with the flow and slower against it. The difference in the velocities of these signals allows the fluid velocity and flow rate to be calculated [13].

Sensors are installed on the outside of the pipe, measuring the time it takes for ultrasonic waves to travel between two points, allowing the fluid velocity to be calculated. It requires no perforation or service interruptions, and it is compatible with real-time monitoring systems. A technical team will install the sensors, without affecting the water supply.

B. Strengths and Weaknesses of the Implementation of Water Flow Sensors

The implementation of flow sensors will improve the efficiency of the water distribution system by monitoring leaks in real time, facilitating the detection of leaks and pressure losses. Also, it will give precise data that will help in decision making, and it will contribute to a more equitable distribution of water. However, the project requires a significant initial investment to buy and install the sensors.

In addition, the dependence on the technology means that any technical failure could affect the operation of the system. Additional training will also be required for monitoring and maintenance people.

IV. Conclusion

In conclusion, the implementation of flow sensors in the urban area of Paraná will improve the efficiency of the water distribution system. By identifying leaks and pressure issues in real time, this technology will allow more homes to have access to a continuous supply of water.

Although the initial investment is high, the long-term benefits for both the community and the environment make this solution an essential step towards a more sustainable and equitable water system in Paraná.

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