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HidroSmart: Water Control and Preservation System

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***Abstract*—*The HydroSmart consists of a system of control and quantification of rainwater, focused on the economy and awareness of water resources, minimizing the withdrawal of the same from the sources and distributors. The system is controlled through a microcontroller programmed to send commands to the water network of a residence. At the same time, the system will send information to a Smathphone via bluetooth. The article will show the step-by-step construction of the HydroSmart prototype to test the feasibility of the system. Thus, with the use of the application the user can access the water consumption. The good performance of the system and the application is an excellent tool that uses the technology to preserve the environment.*
***Keywords*—*Arduino Uno, Water Control.*

I. INTRODUCTION

The change in the rainfall regime on the planet caused by global climate change [1] has also influenced the precipitation regime in Brazil, which could be evidenced by the supply crises in the cities of São Paulo and Minas Gerais in Brazil, in the years of 2014 and 2015 [2]. The supply crisis in the states of the southeastern region of Brazil has caused impacts in several sectors of society such as agriculture, industry and electric energy [3].

The 2015 drought was so severe that it left several cities in the southeastern region without water for days or even weeks, which led the population to seek sustainable alternatives to water use. In order to raise awareness, reduce costs and preserve the environment, technologies for the sustainable use of water have been developed, such as rainwater harvesting in homes and public buildings, reuse of water from air conditioners and household appliances such as washing machines and other.

Although the Amazon region has high rainfall levels, reaching 900 mm during the transition months [4], climate change has also affected rainfall in the region, such as the 2005 drought that caused several rivers to dry up causing death of several aquatic species. On the other hand, the occurrence of torrential rainfall in large cities and the soil sealing process is a consequence of urbanization, which prevents rainwater from infiltrating, increasing surface runoff and causing flooding areas, urban drainage problems, and at the same time decreasing groundwater reserves [5], showing the other face of climate change. These extreme extreme events, followed by events of long periods of drought and water shortages, lead society to think of sustainable ways to use water resources, such as rainwater harvesting.

The technology is a strong ally of sustainable practices, having as one of the main tools automation systems [6][7] and applications for mobile phones [8]. Thinking about this problem, this work will show an option of rainwater control and preservation system, called *HidroSmart*.

HidroSmart is an interactive system that adds rainwater harvesting, controlling and directing the consumption of water in a residence through the use of a SmartPhones application, through which we will try to reduce the waste of water in the residence. In addition, the system still quantifies and shows in a simple way how the user can reduce their daily water consumption, reducing thus, the costs of the water bill and in parallel, reinforce for the population a more sustainable awareness. Through the installation of *HidroSmart* in any SmartPhone the application will show the consumption of water to the day, month and even the year inside a residence, as it will reuse the rainwater, preserving and guaranteeing the preservation of the water sources.

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Thus, this paper will show in section II the construction of the methodology, the materials used during the construction of the prototype and the tests performed with it, and finally in section III we will show the results achieved during the tests with the prototype, in addition to the expected results in one single family residential system, and finally section IV will show a summary of the most significant results presented by the *HidroSmart* system.

II. MATERIAL AND METHODS

The modeling, development, construction and testing of the HydroSmart prototype were carried out during the period from August to October 2018, at the premises of Universidade Paulista - UNIP. The steps that will be described next: II.1, will be shown some of the materials used in the construction of the prototype, while in II.2 a description of the hydraulic system of the HydroSmart will be carried out, being this separated into: network 1, which shows the path of the water coming from the concessionaire and the network 2: rainwater. In addition, section II.3 will show the structure of the HidroSmart application, which counts the general water consumption of the residence.

3.1 MATERIAL

The system was designed with the proposal of being simple and low cost, so that it can be implemented in single family homes in the future. By implementing the HydroSmart you can achieve great savings on the water bill of the residence in which the system was installed. With this in mind, we tried to use the materials available in the market which we tried to associate with characteristics such as durability, quality and low cost. Therefore, Table 1 shows the list of materials used in the construction of the HydroSmart prototype and its respective cost in Manaus during the second half of 2018 (updated value with the value of the dollar on 09/05/2019).

3.2 METHODOLOGY

The hydraulic project consists of two water supply networks (Figure 1), one in which the water source is the utility responsible for the distribution of water in the city, and a second, where the source of the water is the rainwater captured, both controlled by a system of Arduino circuit, which counts the water consumed by the two networks will send to a SmartPhone application.

Table 1: Bill of materials used to build the HydroSmart prototype, and costs

Material	Quantity
Pipeof ½	1
Plywood	1
Clamp	10
Water Tank of the 5 L	2
Water Tank of the 10 L	2
Arduino	1
FlowSensor	1
Relé Module 5V of the 2 Channels	1
Waterlevel sensor	2
Bluetooth Module	1
SolenoidFlowValve	2
Power Supply of the 12V	1
Box Adapter	7
Power Supply of the 9V	1
WaterTap	3
White Pipe of the 50 mm	1
Total CostofMaterials	$ 6.494,76

Source: Authors, (2019).

3.2.1 NETWORK – 1

The hydraulic network of the utility will supply the water that will pass through a solenoid valve and will be at the entrance of the water tank. In this way, the valve will be connected to a flow sensor that will be installed inside the water box which can open or close the water supply system, as well as verify the water consumption. Also, this valve will control the water level, not allowing this overflow, at the same time, through this control will never lack water from the utility in the reservoir of the residence. So that the water of the concessionaire does not lack, in the exit of the box of water will be installed a sensor of flow that will make the reading of passage of the fluid through electrical pulses, thus sending the information to an Arduino Mega circuit.

The electronic prototyping platform used is a single, free board hardware, with 54 pins of digital inputs and outputs, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a power input, a USB connection and an ICSP connection [6]. Its programming is carried out through C ++ Software which is responsible for performing the calculations of the passage of water in days, weeks and even months and years.The water used by the systemcan be used for washing and preparing food and washing clothes and at the end of this system has a flow

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valve that will be closed and will only open in the absence of water in the rainwater catchment tank.

3.2.2 NETWORK – 2

Network-2 is the rainwater collected through a gutter installed on the roof of the residence directing all the water collected to a reservoir, where an extravasor installed in the reservoir does not allow the water to overflow. At the same time, a level float will also be installed in the rainwater reservoir. When the rainwater tank is too low and the remaining fluid can not be used, there will be a flow transfer to Network-1 (water from the utility). Thus, the water will pass through the flow sensor that will count the consumption being controlled by a mobile application. The transport of the water to the reservoir is carried out by means of a hydraulic pump of 127 Volts.

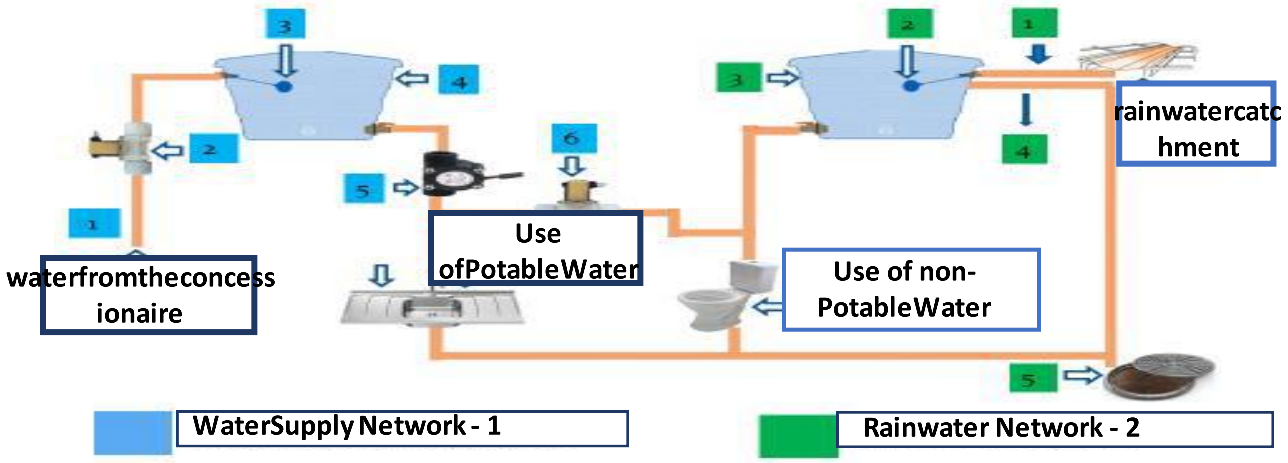

Fig.1: Project Diagram.
Source: Authors, (2019).

Table 2: Label of the Network-1 and Network -2

Network 1 – Concessionaire		Network 2 - Rainwater Harvesting	
1	PVC Pipeofthe ½	**1**	Pipeofthe ½
2	SolenoidFlowValve	**2**	Waterlevel sensor
3	Waterlevel sensor	**3**	Water Tank of the 10 L
4	Water Tank of the 10 L	**4**	Extravasor
5	Flow Sensor	**5**	Sewer
6	SolenoidFlowValve		

Source: Authors, (2019).

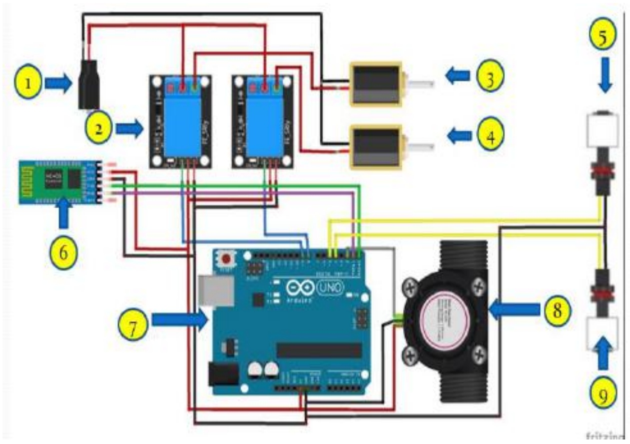

Fig.2: HidroSmart electric scheme.
Source: Authors, (2019).

Table 3: Legend of the Components.

Components	
1	Power Supply of the 9V
2	Relé Module 5V of the 2 Channels
3	SolenoidFlowValve
4	SolenoidFlowValve
5	Waterlevel sensor
6	Bluetooth Module
7	Arduino
8	Flow Sensor
9	Waterlevel sensor

Source: Authors, (2019).

Interconnection of networks – Networks 1 and 2 will be interconnected through a solenoid valve that will always be closed, but at the same time, the communication of each Network and the interaction between them is controlled by a level sensor installed in the rainwater box. lack of water in the reservoir.

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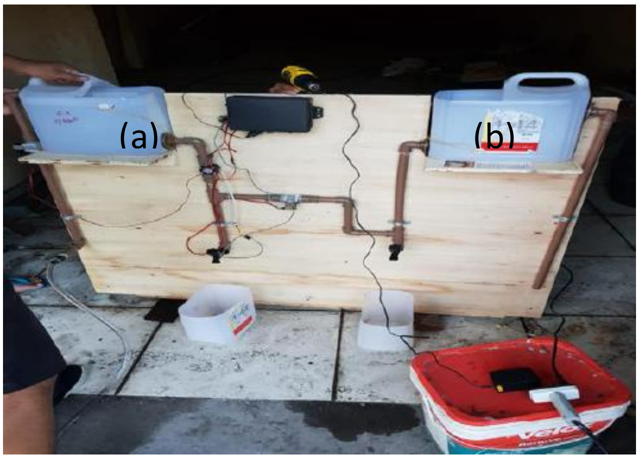

Fig.3: Prototype Assembly. a) Network-1; Simulation of the water reservoir from the concessionaire; b) Network-2; Simulation of the rainwater reservoir.

Source: Authors, (2019).

3.2.3 ROBOREMOFREE

The daily / monthly / annual consumption of water by the user is controlled through a remote-control application (Figure 4), used in Arduino-based projects. Robotooth is a 100% free platform, with no ads or user information collection, at the same time, is limited to 5 items per interface (not counting the menu button, text fields and touch stoppers).

The plots of the can display the real-time data of the sensors, and can be connected to the Arduina board directly through the OTG cable (if the device supports OTG), or use a wireless module which can connect through Bluetooth (Bluetooth SPP -BlueSMIRF, HC-05, HC-06, BTM-222, etc., and / or bluetooth low energy BLE - CC2540, CC2541, etc.) or Wii-Fi.

RoboRemoFree allows real-time control of the flow of water passing through the sensor identified by position "6" in Figure 3, which are converted into the application screen in liters via Bluetooth.

Use plots to display real-time data from sensors, which can be connected to the Arduino board directly using the OTG cable (if the device supports OTG), or the wireless module can be used and connect over Bluetooth or WiFi [10].

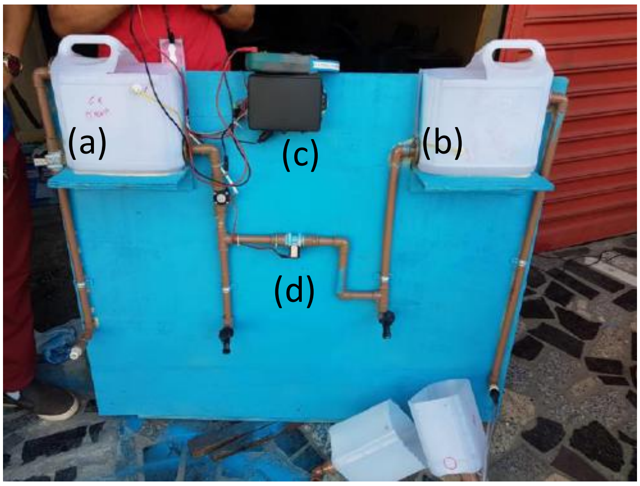

Fig. 6: Prototype. a) Network-1 - Simulation of the water reservoir from the concessionaire; b) Network-2 - Simulation of the rainwater catchment; c) Arduino system; d) control valve.

Source: Authors, (2019).

III. RESULTS

The tests with the prototype were performed in two stages. At first, only the hydraulic system was tested, verifying the incoming and outgoing flows of water from the utility (Figure 5a) and the reservoir (Figure 5b). Once the efficiency of the interaction between the two networks (utility flow and rainwater flow) was confirmed, the Arduino system was implemented, thus showing the first reports of water consumption sent to the application (Figure 7a). Each water outlet was tested separately (Figure 7b).

Through the flow valve it was possible to account for the water consumption of the two reservoirs. The information of the total water consumed in liters/minutes is sent via Bluetooth to the user's smartphone. The losses of water have a direct relation with the energy consumption, thus it was necessary about 0.6 kWh for the use 1m3 of drinking water. This shows that both hydraulic and energy efficiency are key to the proper management of water supply systems.

Figure 7a shows the result of the real-time estimate displayed on the Smartphone screen, in liters per minute of water consumption. Note that when it shows buoy 1 on the screen, it indicates that the valve is releasing the passage of the waters coming from the concessionaire. On the other hand, when this system is deactivated the information that will appear on the screen will be referred to float 2. In Figure 7a, float 1 is activated, releasing the water passage showing a consumption estimate of 2.55 L / min, and subsequently 2.36 L min.

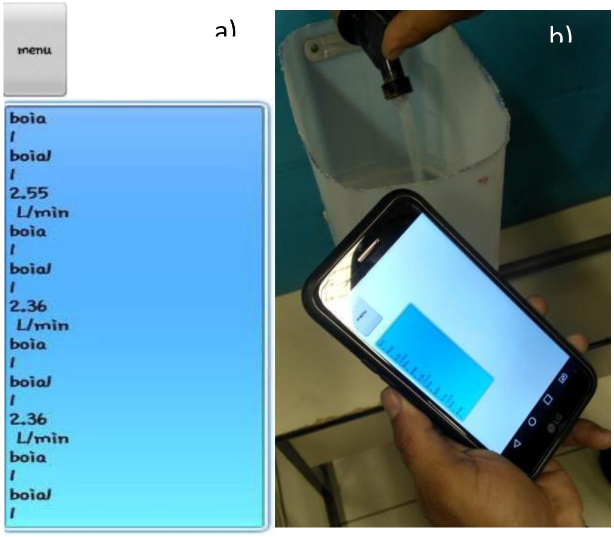

Fig. 7: a) Main screen showing water consumption (liters /min); b) Validation test of water consumption and measured by APP.

Source: Authors, (2019).

Because of the pollutants released daily into the atmosphere, it is not possible to use rainwater for potable purposes, so water collected and stored on Network-2 and used by HydroSmart will be for non-potable purposes only, such as a toilet 6 liters in each use), car wash (average 216 liters in each wash), sidewalk washing (279 liters), gardening (250 liters). Although tests with the HydroSmart prototype showed excellent results and an apparent economy, it was not installed in a residence.

IV. CONCLUSION

During the last decades, society has become aware of the importance of the conscious use of drinking water present in rivers, lakes and even in our homes. The last two droughts in the southeastern and northern regions of the country led the big cities to think about alternative ways of preserving and collecting rainwater. In addition, the latter events require increased attention, showing a strong concern about the waste and the costs of these charged by the concessionaires. Thinking of ways to minimize wastage and sustainable forms that has created HidroSmart.

Using materials that are easy to access and purchase for any user, the systemhas been constructed in a way that does not modify the characteristics of the original hydraulic system of the residence. The system uses two Networks; Net-1, a potable water flow system, which uses only water from the utility; and the Net-2 rainwater system, used only in toilets, car washes and outside areas of the residence and gardening. The opening and closing of the water flow of the networks performed through a valve controlled by an Arduino system.

The flow and water consumption of the two Networks are monitored via Smartphone. RoboRemoFree is a public domain application, free and easy to access to any user. The application is the way in which the Arduino sends the user his or her water consumption every minute. Sending the lit / min information is performed every 60 seconds on the Smartphone screen. At the same time, this information will be stored and made available at the end of each month showing the user the water consumption of the utility.

The project is a way to improve water consumption in homes, leaving portions of pipelines programmed to make distributions in strategic locations and receive rainwater, not only having the primary function of combating water waste, but also generating savings in invoices from water utilities.

Through this tool the user can request information about the water consumption of his residence 24 hours a day, so he can change his habits in situations of water rationing.

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