Lack of Clean Water Access in Rural Schools in Northern Argentina: Air Humidity Water Collection and Dust Filtration Technology to Obtain Clean Water

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***Abstract*— The water scarcity problem is critical in rural schools in northern Argentina, where geographical challenges, limited financial resources and alternative water sources contribute to the lack of water access. The United Nations' Sustainable Development Goals #4 and #6 encompass the problem stated in this paper, and it is a central problem to the 2030 Agenda. Once the drivers of the problem are understood two options will be presented to obtain clean water: Fresh Water Ecco System and the P&G Purifier Packets. Finally, pros and cons of each innovation will be discussed. It is expected that this work might provide insight into this topic that needs urgent attention, and also raise awareness about deficiencies that there exist in some parts of Argentina, and how these affect the education and social development of the inhabitants.**

***Keywords:* water harvesting, water management, water purification, water scarcity, sustainable solutions, educational impact.**

***Resumen*— El problema de la escasez de agua es crítico en las escuelas rurales del norte de Argentina, donde los desafíos geográficos, los recursos financieros limitados y las fuentes alternativas de agua contribuyen a la falta de acceso. Los Objetivos de Desarrollo Sostenible de las Naciones Unidas #4 y #6 abarcan el problema mencionado en este trabajo el cual es un problema central en la Agenda 2030. Una vez que se comprendan los impulsores del problema, se presentarán dos opciones para obtener agua potable: un sistema llamado Fresh Water Ecco System y un producto purificador de agua de P&G. Finalmente, se discutirán los pros y contras de cada innovación. Se espera que este trabajo provea información sobre este tema, el cual requiere atención urgente y que además, genere conciencia sobre las deficiencias que existen en algunas partes de Argentina y cómo afectan a la educación y al desarrollo social de los habitantes.**

***Palabras clave:* recolección de agua, tratamiento del agua, purificación del agua, escasez de agua, soluciones sostenibles, impacto educativo.**

I. INTRODUCTION

Water access is essential to human health, hygiene, and wellbeing. In recent decades, around the world but more specifically in Argentina, the lack of water access, waste, pollution, among other problems, have increased due to human impact. Although this situation has affected the quality of water around the country, schools in rural areas seem to be the most affected. People in rural areas have to use well water because of lack of water services, and sometimes this water is dirty and contaminated. As it can be expected, the lack of water access affects educational institutions in these areas as well.

It is a well-known fact that basic education is important to improve people's lives, as well as job and tertiary education opportunities. However, in rural areas, these objectives are affected by the lack of water in schools. This issue is a central part of the United Nations 2030 Agenda and its 17 Sustainable Development Goals (SDGs) to be achieved by 2030. Among these goals there are two SDGs related to the lack of water access problem. First, SDG #4, whose purpose is to ensure education access in childhood and youth [1, p.27], states how important education is for children and youth. Secondly, SDG #6 aims to ensure the sustainable management of water [1, p.35], which is connected with the use of devices or technologies that can bring clean water to communities that need it.

In Argentina there are many areas with problems related to water access; the north of the country is one of the most affected. This region is characterized by having many rural areas, which are the most affected by high levels of poverty according to the last INDEC report [2, p.4 in Regions results]. As well as this, education continuity in these areas is difficult due to the lack of water access since this causes serious hygiene issues and low nutrition rates that affect school retention rates [3, p.12 in the Results section].

The purpose of this paper is to inquire into the lack of water situation and how it affects students and teachers in Argentinian rural schools in the North of the country. Moreover, it aims to investigate why and how they collect water from unsafe sources and to propose two alternatives to address the issue in order to reduce school dropout rates and improve education quality.

In order to investigate about the lack of clean water access in rural schools in northern Argentina, and to find a solution through sustainable water management devices and technologies, this paper will first describe the problem, explaining the situation of students and teachers in rural schools in relation to the lack of water access. After this, solutions involving a device capable of collecting water from air humidity and a technology composed of a reactive dust that reacts with water and removes dust particles will be proposed. Following this, a feasibility assessment of the two alternatives mentioned above will be introduced. This assessment will determine whether the solution is viable, by

studying its advantages and disadvantages. It is expected that this work might provide insight into this topic that needs urgent attention, and also raise awareness about deficiencies that there exist in some parts of Argentina, and how these affect the education and social development of the inhabitants.

II. Problem Description: Challenges in Rural Areas

Before focusing on solutions to improve the water quality in rural schools, it is necessary to understand why the students have to use dirty water and why there is lack of water access in rural schools. There are persisting challenges connected with dirty water usage and lack of water access in rural areas and the causes are very varied. However, these causes can be divided into three groups.

A. *Geographical and logistical challenges*

Rural schools are generally located in remote areas far away from large cities, and it is very difficult to access basic services such as water. There are also challenges related to the transportation of water due to distance between rural areas and cities.

B. *Limited financial resources and infrastructure limitations*

In big cities there are water treatment plants and large drinking water grids. In contrast, in rural areas this infrastructure is poorer than in cities and residents have to collect water from ground holes, and later storing it in water tanks. This water is saltier than regular drinking water, so people only use this water for sanitation and not for drinking or cooking. Moreover, this water can also damage the household water grid systems.

In rural schools the water is supplied only once a week by the municipality by means of a water delivery truck. Although the supplied water is stored in the school water tank, it lasts only for a single day. This intermittent water supply aggravates the water scarcity problem and forces teachers and students to find alternative water sources.

These infrastructure limitations are generated by the lack of financial resources for rural areas. While large cities have robust financial resources for infrastructure due to their large populations, rural areas generally have scarce financial resources.

C. *Alternative water sources and water contamination*

As stated above, due to water scarcity and the intermittent supply of clean water, teachers in rural schools have to find alternative water sources. The most common alternative sources are the cisterns underground which contain groundwater with high salt content.

This is a commonly reported situation in the rural North. In October 2022, UNICEF (United Nations Children's Fund) arrived in the Argentinian province of Salta in order to improve the water access in rural schools. During this visit, rural teachers talked about the situation of water access and explained that they have to collect water in plastic bottles every morning before the lessons start to supply water to students [4, in the video].

Water from these sources could be contaminated because the cisterns are outdoors, so the water can contain dirt, dead animals, and other kinds of waste. Unfortunately, sometimes this is the only water source in schools, and it is not drinkable.

Due to the three above-stated problems, water access in rural areas is a complex issue and it impacts school life in many ways. Drinkable water is crucial in schools not only personal hygiene but also for cooking because most rural schools have canteens where teachers and students eat every day. The northern region of Argentina is the poorest one of the country [2, p.4 in regions results], and many children do not eat the four basic daily meals [5] so the meal at school is one of the most important ones.

Hygiene is very important for a healthy life and it is not generally ensured because of the lack of clean water and the lack of personal hygiene products. In rural areas, it is of utmost importance to avoid diseases, because there are usually no hospitals nearby. When students need medical assistance, they have to travel long distances, thus missing school days.

As it was stated above, there are several problems related to the lack of water services in rural areas and the lack of clean water access from sources other than conventional ones. It is very important to propose a solution in order to ensure school attendance to improve the education quality in rural schools in northern Argentina.

III. Problem Approach: Air Humidity Harvesting and Water Purification System at Rural Schools

The water scarcity issue requires a system that is capable of harvesting clean water or filtering dirty water from the ground hole in rural schools. Currently, there are several alternatives on the market for both harvesting and filtering water in rural areas. To this end, two methods were selected.

A. *Fresh Water Ecco System*

The Fresh Water Ecco System was created by Fresh Water Company and is made up of a recycled plastic box, shown in [6, Fig 1], which contains a system capable of collecting water from air humidity. This appliance works in the same way as the natural water cycle by which rain is produced recovering the water that is suspended in the air by condensation, collection, filtration, purification, and sterilization. Not only is the box made up of recycled materials, but the company also reuses electromechanical components as well.

Fig. 1 Fresh Water Ecco System [6]

This device contains a water dispenser, wheels to move it and it also works with electricity, as shown in [6, Fig 2]. It takes 24 hours to produce 5 to 28 liters in an average temperature condition 28 °C and 80% relative humidity.

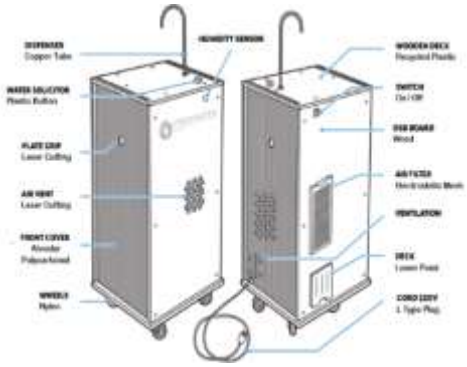

Fig. 2 System Components [6]

The Fresh Water Ecco System only works in a temperature range from 15°C to 40°C with a humidity range from 35% to 95%. Water production will be faster or slower according to climate conditions.

This system is very useful to collect and provide clean water in rural schools. However, it does not have high storage capacity; it holds only 12 liters. Based on the number of students the school has, it probably will need several devices to ensure the necessary water production.

B. *P&G Purifier Packets*

The P&G Purifier Packets technology, which was developed by P&G company, is composed of a powdery material which is able to chemically react with water to obtain clean water, as shown in [7, Fig. 2]. One purifier packet is capable of quickly turning 10 liters of dirty water into clean and drinkable water. One packet contains 4 [g] of material.

Fig. 3 P&G Purifier Packets [7]

To obtain clean water, the content of one P&G water purification packet is first poured into a bucket with 10 liters of water. Then, the water has to be stirred in order to evenly distribute the powdery material. After this, the dirt will settle at the bottom of the bucket because of a chemical reaction between the water and the P&G's powdery material. Finally, before drinking, the water has to be filtered using cloths or fabrics to eliminate the settled waste.

In order to ensure the correct usage of these devices it is important to propose a post construction support using management models. An important management model is the Community Management Model, where a group of people from the community is in charge of the operation, maintenance and billing of the system.

IV. Feasibility Assessment: Advantages and Disadvantages of the Proposed Technologies

In this section a feasibility assessment will be done over the proposed methods. The purpose is not to select only one method, it is to state the advantages and disadvantages of each and to determine their feasibility and implementation conditions.

Rural school conditions in relation to energy access, economic resources, among others, will be taken into consideration to state if the method is feasible or not. Improvements could be proposed to overcome the obstacles presented by a device.

Fresh Water Ecco System's principal advantage is that the device is automatic, producing water by itself without human intervention, so workers and students will not have to consume energy for collecting water. The device can also filter and sterilize the collected water, which is useful in areas with air pollution where the harvested water could be contaminated.

Although these are great advantages for a system, it also has prominent disadvantages. First, the need for electric energy to operate, the fact that the device has to be connected to the electrical grid to work would be a problem in schools without electrical connection. Secondly, strict operation conditions are needed to produce 5 to 28 liters in 24 hours. The conditions of 15 °C, with an air humidity of 35 %, average northern region conditions in winter, are the worst to operate the system. If this were the case, the device could only produce 5 liters in 24 hours. Finally, if the device produces more than 12 liters of water, it could not store them because it has only 12 liter of storage capability. Because of the slowness of water production and the low storage capacity, a school would need more than one device to ensure water production, making it more expensive.

The Fresh Water Ecco System could be improved in relation to the fact that it needs electric-energy by installing a solar panel to power it. The implementation of a solar panel may allow the deployment of this device in a rural school without electrical grid.

The P&G Purifier Packets technology provides a fast method to clean dirty water using only one packet. However, the implementation of it requires that a person should work in pouring, stirring, settling, and filtering, these actions would need human energy and the time spent would be approximately 30 minutes [8, in operation section]. In comparison with the Fresh Water Ecco System, the P&G purifier packets need human intervention to work because they do not produce clean water by themselves.

The use of Fresh Water Ecco system would be recommended if the school has robust financial resources, because it could need more than one device and could need the installation of solar panels. If the school has a tight budget, they could use the P&G purifier packet technology to clean water from sources other than conventional ones sources, such as ground water from water wells.

Whatever choice is made, it is important to state that after deploying the solutions in the rural schools there has to be training about how to operate and maintain the systems. Also,

it is important to ensure the participation of the students and teachers in the design and implementation process of the system because doing this they develop a sense of ownership over the system.

V. CONCLUSION

In conclusion, it can be said that water shortage in rural schools affects educational quality and personal hygiene. This problem can be addressed using the systems proposed in this paper. However, the problem will not be solved in the long run only with the two proposed devices; large economic investments and actions are needed to solve the underlying problems in the northern region of Argentina that allow infrastructure to be improved.

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