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Fog Capture and Its Potential Use Irrigation and Human Consumption, Lima - Peru

Vladimir León[13], Alexi Delgado[2], Noemí Herrera[3], Kiara Aguirre[3], Estefany Valverde[4], Edson Palacios[3]
[1]Centro de Investigación Interdisciplinar Ciencia y Sociedad, Universidad de Ciencias y Humanidades, Lima, Perú
[2]Department of Engineering, Mining Engineering Section, Pontificia Universidad Católica del Perú, Lima, Peru
[3]Facultad de Ciencias del Ambiente - Universidad Nacional Santiago Antúnez de Mayolo, Huaraz - Perú
[4]Facultad de Ingeniería Química, Universidad Nacional de Trujillo, La Libertad, Perú
vleon@uch.edu.pe; epalaciosr@unasam.edu.pe

Abstract – Fog catchers could be an alternative to make up for the lack of water in shanty towns, either for irrigation or human consumption. These have demonstrated average catchments of up to 9 l/m^2/d generated during the winter, and technologies such as baked clay filters can treat any type of water showing high efficiency in the elimination of pathogens, metals and other contaminants. Therefore, the present investigation aimed (1) to determine the volume of water generated by 2 standard fog catchers, (2) to evaluate the quality of collected water with potential use in irrigation, and (3) to evaluate the quality of collected water treated by baked clay filters with potential use for human consumption. Results show that the maximum collected water volume for the two fog catchers are 17.1 l/m^2/d and 21.1 l/m^2/d respectively. Characterization of the directly captured fog water sample can be used in irrigation without restriction. Fog water captured and filtered through a clay filter meet maximum permissible limits for human consumption according to peruvian regulations, except for fluoride (1.50 mg F^-/L) and pH (10). However, it's suggested to treat the water with another alternative. Species recommended for shanty towns are Molle serrano (*Schinus molle*), Tara (*Caesalpinia spinosa*) and Tipa (*Tipuana tipu*) because they can adapt to extreme conditions of aridity and stress, and require low amounts of water.

Keywords**:** Fog catcher, irrigation, human consumption, clay filters, shanty towns.

1. Introduction

Peru is divided in three natural regions known as the coast, mountains and jungle. The coast has an area of approximately 11% of the national territory, mountains represent 27%, and the jungle covers the majority with 62% [1]. 70% of peruvian population lives on the coast, where there has been progressive migration from the jungle and mountains in recent years, particularly to the capital city of Lima, where more than 10 million people live (33% of the population) [2]. As a result of this situation, shanty towns have been generated, which are considered as group of families "settled" around large cities. It's estimated that more than 1.3 million inhabitants in Lima live in shanty towns [3], these are characterized by the lack of legality of occupation of the territory and basic services such as water, drainage, security, solid waste, green areas, education and electricity [2] (Fig.1).

The main problem of these shanty towns is the limited access to the drinking water network, being supplied mainly by tanker trucks, which generally imply higher costs for the population, compared to the tariffs of a public network [4]; in addition, it's a discontinuous service, which often provides water that doesn't comply with the water quality standards for human consumption [5]. Low availability of water in shanty towns in terms of quality and quantity puts the food security and health of the inhabitants at risk. Diseases such as cholera, diarrhea, dysentery, hepatitis, typhoid fever, and dengue fever are associated with the lack of this resource, causing an increase in medical expenses and increasing poverty [6]. Added to this is the current pandemic situation due to Covid-19, which generates great concern, since hygiene practices and washing are limited, which are a priority to avoid contagion [7]. According to the World Health Organization (WHO), about 9 m^2/hab of green areas are required [8], Lima barely has between 2-3 m^2/hab, worse yet shanty towns are estimated between 0.5-1 m^2.hab [9].

Currently, there are technologies such as fog catchers widely used in coastal areas, they are known as fog catchers. These are devices that are used to capture the liquid content of the fog with a nylon, propylene or polyethylene mesh [10]. These can be implemented in different sizes and configurations that allow conducting the collected fog water to storage tanks and subsequently can be given different uses [11]. According to some experiences, the most efficient fog capture is the standard

fog catcher (SFC), which compared to others allows the highest collection of up to 9 l/m^2/d of water [10], water that can be used in the irrigation of shanty towns in Lima, which has <2% of the water reserves in the whole country [12]. Water can be also treated for human consumption, decentralized systems of baked clay filters have demonstrated efficiencies >90% removal of pathogens, heavy metals and other contaminants, which allows drinking water directly after filtration [13].

Therefore, the present investigation aimed (1) to determine the volume of water generated by 2 standard fog catchers, (2) to evaluate the quality of collected water with potential use in irrigation, and (3) to evaluate the quality of collected water treated by baked clay filters with potential use for human consumption.

2. Methods

Research was carried out in 3 contiguous shanty towns located in the highest locations in Lima (>500 m) (Fig. 1), which are located between the limits of the districts of San Juan de Miraflores, Surco, and La Molina.

Fig. 1. Left: Typical shanty towns in southern Lima. Right: 3 contiguous shanty towns.

In order to determine the amount of water generated by each SFC, the following was considered: (1) 02 SFC (2x3m) were strategically located under the same climatic conditions with projections of generating and supplying water to the 3 shanty towns, then (2) SFC were built mainly with round wood, raschel mesh of 35% shade on both sides, gutter, pipes and a storage tank and finally (3) readings were taken every day at the same time for 22 days of the volume of water generated.

To determine the quality of the captured water with potential use in irrigation and human consumption, two composite samples NEBO1 (sample of collected water) and NEBO2 (sample of water collected and filtered through a baked clay filter) were analyzed. The main parameters analyzed for water samples for both irrigation and human consumption are based on peruvian regulations, such as the Environmental Quality Standards (DS N° 003-2010-MINAM) and the Regulation of Water Quality for Human Consumption (DS N° 031-2010-SA) respectively.

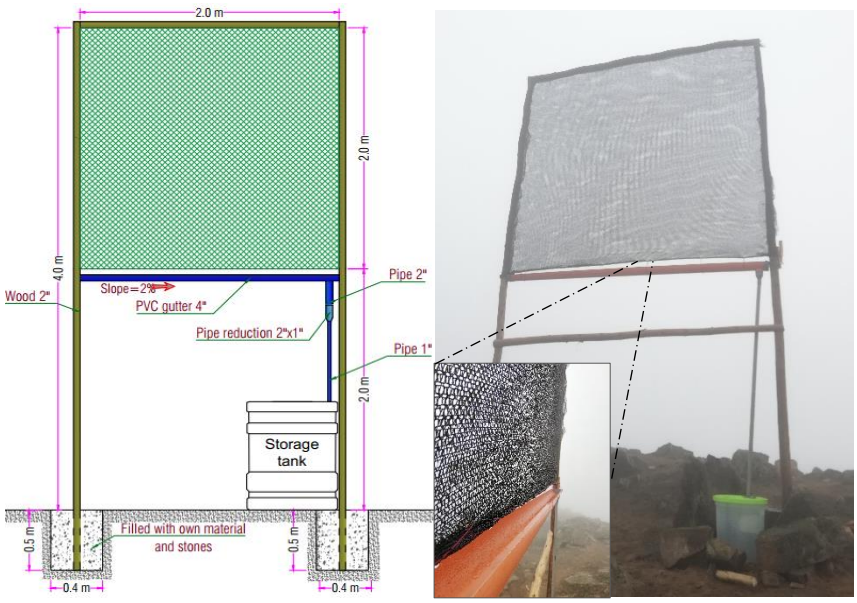

Fig. 2. Left: Details of installed SFC; Right: SFC installed in shanty towns.

3. Results

After 22 days of monitoring the generation of water collected in the fog catchers (Fig.3), we can observe that they present irregular fluctuations, this is due to the fact that the evaluation period was just beginning in the coastal winter, however, the maximum amounts generated in fog catcher 1 and 2 are 17.1 l/m^2/d and 21.1 l/m^2/d respectively. Preliminary results show that the maximum amount generated may still be higher.

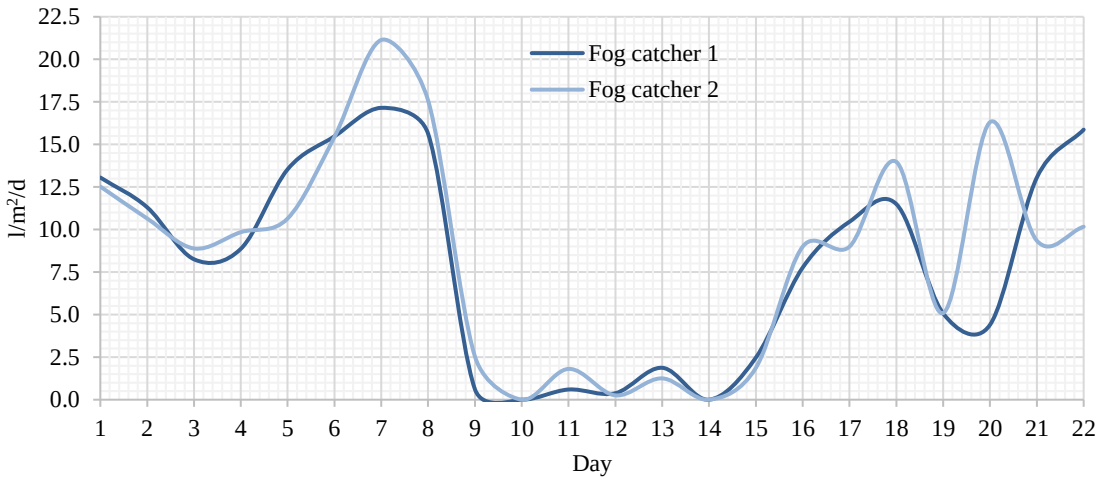

Fig. 3. Volume of water generated in fog catchers 1 and 2.

The characterization of the fog water samples can be used directly in irrigation without any treatment (NEB02) because the parameters evaluated didn't exceed the levels of peruvian regulations. On the other hand, the filtered fog water sample (NEBO2) comply with the maximum permissible limits to be considered for human consumption, except for pH: 10 (6.5 - 8.5) and fluoride: 1.5 (<1 mg F^-/L).

Also, Lima, being located in a subtropical desert, is an area of forestation with species adapted to aridity and drought conditions. Therefore, the recommended species that could be implemented in the 3 shanty towns would allow greater ecosystem benefits because they provide oxygen, soil formation, scenic beauty, regulators of the environment against climate variation, and they harbor a great diversity of species of flora and fauna [13].

Table 1: Plant species that can be adapted to shanty towns.

Species	Life	Altitude (m)	water consumption ($l/m^2/d$)
Molle serrano (*Schinus molle*)	Annual	4 - 8	0.68 – 1.64
Tara (*Caesalpinia spinosa*)	Annual	12	0.63 – 1.37
Tipa (*Tipuana tipu*)	Annual	8 - 12	1.10 – 2.74

Fuente: Reynel et al., 2008

4. Conclusion

The maximum quantities generated in fog catcher 1 and 2 are 17.1 $l/m^2/d$ and 21.1 $l/m^2/d$ respectively. However, it is monitoring is suggested the amount of water generated over a longer period.

Characterization of the collected fog water sample (NEBO1) can be used in irrigation without restrictions.

Characterization of the filtered fog water sample (NEBO2) shows that the parameters that exceed the maximum permissible limits of the peruvian standards are fluoride (1.50 mg F^-/L) and pH (10). However, with better treatment it can be used for human consumption.

The recommended species that could be planted in shanty towns are Molle serrano (*Schinus molle*), Tara (*Caesalpinia spinosa*) and Tipa (*Tipuana tipu*) because they can adapt to extreme conditions of aridity and drought, and low water requirements.

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