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Aquapot: UF real applications for water potabilization in developing countries. Problems, location and solutions adopted

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Abstract

Lack of safe drinkable water is a serious problem that affects people in developing countries, conditioning health, social and economic development. AQUAPOT project, has researched and developed the use of membrane technology as an effective method to obtain drinkable water from surface water in developing countries. AQUAPOT has also designed, built and installed a membrane-based facility. Placement and assembly of the designed potabilization plant, is done after the area recognition. The location study includes the identification of the main technical, cultural and social characteristics in the local situation. The place chosen to install the UF designed plant, is an urban area, with a population of around 1000 inhabitants, located in a mountain region of Ecuador, with no drinkable water and with a surface water supply from a reservoir, where just a settling is done. The analytical results of feed, permeate and concentrate samples from the last six months, conclude that the UF-facility designed works properly and allows to obtain drinkable water in the studied region.

Keywords: Drinkable water, Ultrafiltration, Developing Countries, AQUAPOT, Children health.

1. Introduction

Lack of safe drinkable water is a serious problem that affects people in developing countries.

In the world, over one billion people still use unsafe drinking water sources [1]. Each year, 1.6 million of children die from diarrhoea and other water-, sanitation- and hygiene- related

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diseases and many more suffer and are weakened by illness.

In developing countries, the absence of water treatment technologies is due to the lack of economical resources and suitable infrastructures. People are forced to use household water treatment that has a lower economical cost but a variable efficiency, due to unhygienic storage and handling practices. The most typical examples are boiling and chlorine bleach addition.

Since 1996, Chemical and Nuclear Engineering Department from Polytechnic University of Valencia has developed an international project called "AQUAPOT: Water potabilization in developing countries". The aim of this project is the design and construction of a potabilization facility based in the ultrafiltration (UF) technology, to produce drinkable water.

After 9 years of research work in the laboratory and in a pilot plant, AQUAPOT project has obtained promising results with UF membrane facility designed and has confirmed the technology as an effective method to treat superficial water, with high microbial content.

The UF facilities designed are modular, economical, simple, effective, with easy automation, and doṅt need the addition of chemicals to produce drinkable water.

In 2004, AQUAPOT project installs a potabilization facility in a rural area of Ecuador, with no access to safe water.

2. Methods

2.1. Technology

People from rural areas of the Azuay province in Ecuador, are supplied with water from rivers and lakes. This water is not drinkable because it contains a high amount of faecal microorganisms, due to the free access of the animals to these water sources.

The previous research work done in AQUAPOT project, showed that UF is a suitable membrane technology to obtain safe potable water from surface waters [3,4] and allowed to select the best UF membrane according to the feed water characteristics [5]. For that, UF is the membrane based technology selected for the application in a rural area of Ecuador.

Ultrafiltration is a well-known separation technology that can retain macromolecules or high molecular weight substances, as well as colloidal and suspended mater. UF also excludes bacteria and viruses, which allows its application for water disinfection, producing drinkable water as the permeate of the process [6].

UF technology has also many advantages as constant production, compact process and plant, easy automation and low energy consumption.

2.2. Location protocol

The methodology followed to locate the UF facilities is composed by: the analysis of the water supply in the community, the study of the location to select the best placement (including the technical, social and cultural characteristics of the region) and the analysis of the water sources.

The selected region for the real application is Giron (Ecuador). Giron is one of the 15 regions in the Azuay province, with a population of around 1000 inhabitants.

The protocol includes the following items:

Technical analysis of the drinkable water in the community: analysis of the water supply and evaluation of the water sources: Water supply in the Giron community comes from a kind of gully called "quebrada". Water treatment before distribution to the houses, is just chlorination.

Nevertheless tap water is not drinkable, due to pressure drops, losses and other intermittent pressure changes, deteriorated, open

or leaking conveyances and other distribution system deficiencies lead to infiltration or intrusion of contaminated water which helps to increase bacterial growth inside the pipes and reduces the efficiency of the chlorination done in the head of the network.

Even so, local people drink tap water after boiling it or buy bottled water if the economical situation allows it.

People, who live in small communities in the andin region near Giron, have no access to the water distribution network and drinks water from rivers or lakes, carrying the water in tanks to their houses.

Location study: The best location for the UF membrane facility is determined after the evaluation of the following characteristics:

- Technical items: distribution system, water storage and water origin point.
- Social and cultural characteristics: intake and water uses of the population.
- Location factors:
- Proximity to village
- Simplicity to install pipes
- Easy access to the UF-facility
- Hydrostatic pressure (manometric height in meters, from the water origin to the plant's feed)
- Simplicity to distribute the drinkable water produced
- Security against damages or other kind of incidents
- Distance from the water origin point to the UF facility location (in meters)

Local factors considered: Nowadays, Giron is suffering a deep economical crisis, that has forced people to migrate to other villages and countries. The main economical activity in the region, is the agriculture and pasturage, and the families live of selling their own products, as for example, milk and fruits.

With the aim of improving the economical situation, a small company called "Agro-food Corporation of Giron" has been created to produce milk and meat based products. This company belongs to 223 families from Giron, and needs the sanitary certification to initiate the food production. To obtain this permission a safe water supply is needed.

2.3. Location selected

After the location study and the technical analysis, the best location for the UF facility is next to the agro-food company. The drinkable water produced is divided between the industrial process and the human intake.

3. Results and conclusions

The technical travel to Giron (Ecuador) inside the real application of the AQUAPOT project has allowed:

3.1. The installation of the water potabilization membrane facility with a capacity production of 2000 L/h

The water that feeds the potabilization membrane facility comes from a gully situated at 700 m high, near the agro-food company. Surface raw water comes into a reservoir tank, where a settling step is produced, before being canalized to the potabilization plant.

Working conditions for the designed plant are:

- Feed flow: 2500 L/h
- Working pressure: 2.5 Kg/cm^2. The system installed, works by hydrostatic pressure, and doesn't need pumping work to produce drinkable water.

Fig. 1. shows the flow diagram of the UF plant located in Giron (Ecuador).

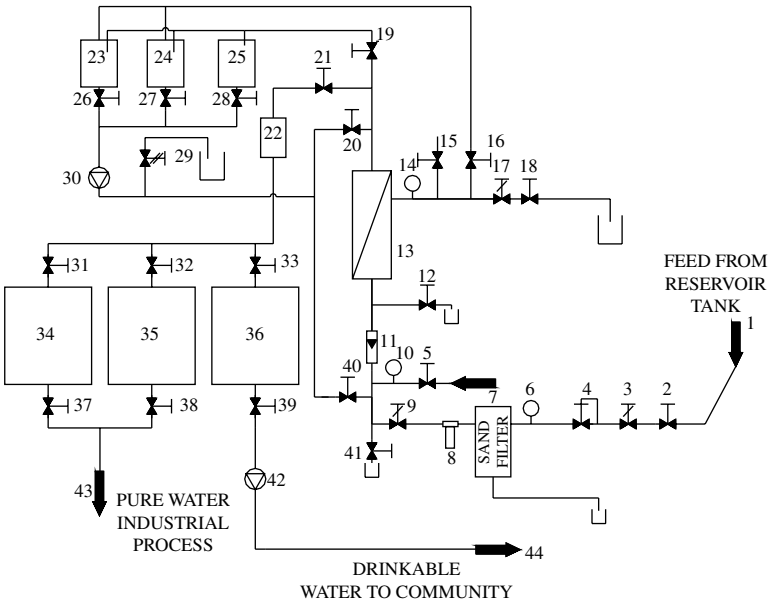

Fig. 1. Flow diagram of the plant installed.

The system installed has a sand filter of 300 μ (7), a 50 μ previous filter (8) and a membrane module (13) with UF hollow fiber membrane made of poly-ether sulphone (PES) with a "cut-off" of 150 KDa. The water produced is stored in three tanks (34,35 and 36) of 2500 L capacity, using two of them in the industrial process (43) and the other for distribute drinkable water to the Giron inhabitants (44).

As a result of the potabilization plant installation:

- Pure water (1500 L/h) for the production in the agro-food company is given. Consequently, the company has obtained the official sanitary permission to produce milk-based and meat based products.
- Drinkable water for human consumption (500 L/h) is obtained. A fountain has been built next to the company entrance, with free access. People can fill the tanks and bring them home when they go to the company to buy products or bring the milk or meat to the production process.

Fig. 2 shows a picture of the system installed.

3.2. Improve the quality of the water that supplies the membrane facility

Due to the frequency and intensity of the rains, the composition of surface water changes, so the primary design was completed with a pre-treatment system based on a filtration step, through metal grids with different pore size and a disinfection step, using chlorine. In that way, suspended solids content is reduced and the quality of the feed water is improved

3.3. Confirm the UF as an accurate technology to obtain drinkable water in a real application

The analytical results of feed, permeate and concentrate samples from the last six months, conclude that the UF-facility

Fig. 2. Picture of the system installed in Giron.

Table 1
Analytical results from feed, permeate and concentrate samples

	Method	Units	Feed	Permeate	Concentrate
Total alkalinity	SM 2320 B	mg $CaCO_3$/l	64.6	68.7	64.6
Conductivity	SM 2510 B	μS/cm	120	130	113
Total hardness	SM 2340 B	mg $CaCO_3$/l	57.1	55.2	55.2
Turbidity		NTU	0.85	0.28	0.61
pH	SM 4500 H B		7.05	7.63	6.49
Total coliforms	SM 9221 E	NMP/100 ml	900	<2	>1000
Thermotolerants Coliforms	SM 9221 E	NMP/100 ml	70	<2	170

designed works properly and allows to obtain drinkable water in the studied region.

Table 1 shows the results obtained in the Giron potabilization plant.

These results, allow to conclude that the installed system improves the quality of the surface water treated, removing the pathogens microorganisms and represents an effective method to obtain safe drinkable water in the Giron canton.

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