WILDERNESS & ENVIRONMENTAL MEDICINE, **27,** 379–385 (2016)

ORIGINAL RESEARCH

Point-of-use Unit Based on Gravity Ultrafiltration Removes Waterborne Gastrointestinal Pathogens from Untreated Water Sources in Rural Communities

Cristóbal Chaidez, PhD; Juan R. Ibarra-Rodríguez, PhD; José Benigno Valdez-Torres, PhD; Marcela Soto, PhD; Charles P. Gerba, PhD; Nohelia Castro-del Campo, PhD

From the Laboratory of Environmental and Food Microbiology, Centro de Investigación en Alimentación y Desarrollo, A.C., Unidad Culiacán, Sinaloa, México (Drs Chaidez, Valdez-Torres, and Castro-del Campo); the Consejo Nacional de Ciencia y Tecnología-Centro de Investigación en Alimentación y Desarrollo, A.C. (Dr. Ibarra-Rodríguez); the Soil, Water and Environmental Science Department, University of Arizona, Tucson, Arizona (Dr Gerba); and the Facultad de Ciencias Químico-Biológicas, Universidad Autónoma de Sinaloa, Ciudad Universitaria, Culiacán, Sinaloa, México (Dr Soto).

Objective.—In developing countries, rural communities often face the lack of potable water infrastructure and must rely on untreated sources for drinking, which are often contaminated with waterborne pathogens. The use of home water treatment devices is seen as one means of reducing the risk of exposure to waterborne pathogens. The aim of this study was to evaluate the microbiological and physicochemical performance of a simple in-home point-of-use device based on gravity ultrafiltration through an ultrafilter membrane.

Methods.—Twenty-five randomly selected households from 2 rural communities in Culiacán, Mexico, were enrolled. Water samples were collected before and after treatment and during storage for a period of 8 weeks. Heterotrophic bacteria, total coliforms, fecal coliforms, *Escherichia coli*, and *Giardia* spp were quantified, as well as various physicochemical parameters.

Results.—All of the untreated water samples contained high levels of indicator bacteria, but none were detected in the treated water fulfilling the requirements set by the Mexican Norm (NOM-127-SSA1-1994) and the World Health Organization guidelines for drinking water. However, indicator bacteria (fecal coliforms and *E coli*) were detected in every sample from water stored 24 hours after treatment.

Conclusion.—This study demonstrated that point-of-use filters using gravity-fed ultrafilters are a low-cost, effective water treatment technology for water of poor microbial quality. However, further identification of the sources and mechanisms by which water is contaminated when stored after treatment will help with designing and implementing better strategies for keeping water safe for domestic use.

Key words: developing countries, drinking water, water treatment, microbial contamination, fecal bacterial indicators, *Giardia*

Introduction

An estimated 750 million people worldwide lack access to safe drinking water.[1] Contaminated drinking water, along with poor sanitation and hygiene, contributes annually to 4 billion cases of diarrhea and 1.9 million deaths in developing countries, affecting mostly young children.[2] The lack of access to safe water has been addressed as one of the development goals established in September 2000 as part of the resolution adopted by the General Assembly during the United Nations Millennium Declaration.[3]

Potable water infrastructure in developing countries is not accessible to many rural communities in which demand has made it necessary for consumers to collect

Corresponding author: Nohelia Castro-del Campo, PhD, Laboratory of Environmental and Food Microbiology, Centro de Investigación en Alimentación y Desarrollo, A.C., Unidad Culiacán, Sinaloa, México, Carretera a Eldorado Km 5.5, Campo El Diez, CP 80110 (e-mail: ncastro@ciad.mx).

Submitted for publication September 2015

Accepted for publication May 2016

water from untreated sources, such as wells, springs, boreholes, rainwater, and surface water. This requires communal water storage tanks, encouraging collection and storage for further use at the household level, hence frequently leading to high levels of fecal contamination.[4]

In northwest Mexico, almost 100% of the urban population has access to potable water, but some rural communities remain devoid of safe drinking water and sewage infrastructure. Surface water in northwest Mexico is plentiful but often at risk of contamination due in part to inadequate wastewater treatment in rural communities. Efforts made in rural communities to avoid contaminated water include the use of shallow wells. However, such wells are not adequately protected and may be susceptible to contamination. In addition, contamination may occur during collection and storage in the home.[5,6]

As reviewed elsewhere,[7–9] improvements in household water quality are associated with substantial reduction in diarrheal diseases. Some of the least expensive interventions applied to minimize microbial contamination include chlorination, flocculation/disinfection powder, solar disinfection, and ceramic or slow sand filtration. Among these intervention methods, filters have been shown to be one of the most effective methods in removal of waterborne pathogens.[7] Point-of-use (POU) technology based on ultrafiltration has demonstrated not only improved drinking water quality but also reduced diarrheal diseases.[10,11] The aim of this study was to evaluate the microbiological and physicochemical performance of an in-home POU device based on gravity ultrafiltration (LifeStraw, Vestergaard Co.).

Methods

STUDY AREA

This study was conducted in 2 rural communities in Culiacán, Sinaloa, Mexico, from October through December 2011. Culiacán, capital city of the state of Sinaloa, has an urban population reaching almost 1 million inhabitants, and close to 40,000 rural population. Two of the oldest and poorest rural communities in Culiacán are El Rincón de los Monzón (52 inhabitants) and Pueblo Nuevo (55 inhabitants), with geographical coordinates of 25°03’35.18 N 107°39’38.60” W and 27°03’51.80 N 107°39’38.60” W, respectively.

The main source of water for drinking and household purposes is extraction from wells located near the Humaya canal. The water is transported to households in large open containers posing a risk of potential contamination. Both rural communities (El Rincón de los Monzón and Pueblo Nuevo) were chosen according to the following criteria: lack of access to potable water, sewage infrastructure, and sanitation habits. Household members involved in the study gave their consent to participate, and the respective households were defined as “case households.”

The filtration units were installed according to the manufacturer’s instructions in each of the 25 participant households (16 units were installed in El Rincón de los Monzón and 9 in Pueblo Nuevo). After the device was installed, the participants received a brochure and training for the correct use and proper cleaning of the unit in accordance with the manufacturer’s instructions. Participants were also instructed on consumption and storage of the treated water. Data on the approximate quantity of water treated, the periodicity of unit maintenance, the water source employed, and any specific unexpected events were provided by the participants each week before sampling.

THE WATER TREATMENT SYSTEM

The LifeStraw Family 1.0 is a fully integrated, gravity-fed ultrafilter, low-cost, POU microbial water treatment system intended for routine use in low-income settings. The unit is designed to treat water of unknown microbiological quality with high levels of turbidity and works at low pressure without any power source requirement. The low cost of this device is due to the fact that once the device is acquired there is no need for additional products, reagents, or electricity. The unit has a cost of about USD $90. The LifeStraw Family 1.0 is designed to produce approximately 150 mL/min (9.0 L/h) of water with a lifetime capacity of about 18,000 L, which would provide a 5-person family with treated water for 3 years. Using the foregoing assumptions, this works out to less than USD $6/person/year. The unit cost would be USD $0.005 per liter treated.

The ultrafiltration method can remove particles in the range of 2 to 50 nm or larger depending on the pore size of the membrane used. This pore size is small enough for the removal of viruses and bacteria. The LifeStraw Family 1.0 has an ultrafiltration membrane in a cylindrical plastic cartridge (dimensions: 26 × 3 cm). Water passes through narrow fibers under gravity-induced pressure.

Source water is introduced into the system by pouring 2 L into a feed water bucket with an 80-μm prefilter. The water passes through the cleanable prefilter mounted inside the feed water bucket and then through a halogen chamber that elutes low amounts of active chlorine to help prevent membrane fouling (a small amount of active chlorine slows biofilm formation on the hollow fiber membrane). A 1-m plastic hose connects the halogen chamber with a cartridge that contains the 20-nm pore size hollow fiber membrane in which ultrafiltration takes place (Figure).