FINAL REPORT

NICARAGUA

HOUSEHOLD WATER SUPPLY AND TESTING PROJECT

by

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December 1993

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1.0 Introduction

Water suitable for drinking is often very difficult to find or produce in the rural areas of Nicaragua. Though considerable progress has been made to ensure that potable water is available to cities and towns, up to 88% of the population outside of major population centres are unable to access safe drinking water. Virtually 100% of farm households have no access to safe drinking water. It is estimated that 48% of the entire population of Nicaragua cannot be adequately served by any existing or proposed potable water supply programs. Cholera epidemics are common and devastating to the communities in which they occur. (Personal communication with PAHO(Nicaragua), Nicaragua Ministry of Health (MINSA) and Nicaragua Ministry of Water and Sanitation (INAA) staff.)

2.0 Technical Background

A serious problem facing those who wish to assist the rural communities in obtaining suitable drinking water is the selection of the technology to be used. The technology chosen must not only perform its intended purpose, it must be affordable, culturally acceptable and very well understood by the people who will be using it. In short, the technology must be appropriate and sustainable. Despite the existence of a vast knowledge base on water supply development and treatment, only a few solutions may be recommended for use in rural communities.

Uncontaminated water supplies may be obtained from borehole wells and springs. However, to be affordable the costs for construction, operation and maintenance need to be shared by an informed and organized community .These water supplies may be contaminated, and frequently are, if they are not operated correctly.

In situations where uncontaminated water cannot be found, treatment is the only available solution. The water can be boiled but fuel may be expensive or unavailable. Chemicals such as chlorine and iodine, commonly used for water disinfection, may be considered expensive and sometimes undesirable (taste, odour etc.). Simple water filters, such as recommended by the World Health Organization 1987 and common to many peoples of the world, are not intended to and cannot provide the quality of treatment necessary to produce pathogen free water .

.0" Slow sand filtration, (SSP), has been successfully used for water treatment since the mid-nineteenth century, Huisman and Wood 1974. It was developed to economically treat large amounts of water which would then be available for distribution. Removal rates of total and faecal bacteria vary between 99 to loo percent, Bellamy et al. 1985a and Bellamy et al. 1985b. (It is important to note that the bacteria responsible for cholera, Vibrio Cholerae, is very similar to E. coli bacteria, (faecal coliform bacteria), with respect to its shape, size and how it lives and can be expected to be removed at rates very similar to E. coli.) Removal rates of viruses are reported to vary between 99.9 to 100 percent depending on filter design, Hendricks and Bellamy 1991. Removal rates of cysts of Giardia and Cryptosporidium, which are both resistant to disinfection, are reported to be greater than 99.99 percent, Bellamy et al. 1985a and Schuler and Ghosh 1991. Removal of schistosome cercariae, the cause of schistosomiasis, is estimated to be 100 percent, Bernarde and Johnson 1970. Concentration of total or E. coli bacteria measured in terms of number of bacteria per 100 ml. of sample are used as measures of potential contamination of water by pathogenic organisms. Slow sand filters will significantly reduce turbidity, colour, and concentrations of mercury, cadmium, chromium, lead, iron and manganese, Erb et al. 1982 and Seppan 1992. Communities throughout the world with populations ranging from as few as fifty people to those with several million people are using SSP technology successfully. SSP technology~ has never been successful~ adapted for use by individual households such as those found in the rural areas of Nicaragua.

The reasons for the lack of development of SSP for individual household use may only be guessed at. Typically research is directed towards the development of technology which would benefit the greatest portions of the population. Intermittent use of SSP, which would be normal for individual households, seriously reduces the performance of larger scale continuous flow slow sand filter, (CFSSF), water treatment facilities, Paramasivan et al. 1980. CFSSF's are never designed to be intermittently operated.

3.0 Project Development

In the fall of 1991 research into intermittently operated slow sand filters, (IOSSP), was initiated in the Department of Civil Engineering of the University of Calgary, Lee 1991. The results of this research supported new theories regarding the mechanisms responsible for the removal of pathogenic organisms from water by slow sand filtration. Initial positive results and the development of an inexpensive portable laboratory also in the Department of Civil Engineering of the University of Calgary, Dean 1992, convinced the Pan American

Health Organization, (P AHO), through the Centro Latinoamericano de Perinato1ogia y Dessarollo Humano, (CLAP), to invest US $10,000 from one of its projects known as Proyecto de Desarollo de la Salud Perinatal, (DESAPER) into a pilot IOSSF technology evaluation project in Nicaragua. DESAPER is funded by the Canadian International Development Agency, (CIDA), and is co-administered by the Division of International Development of the University of Calgary and CLAP. DESAPER has two projects in Nicaragua, one in Nandaime and the other in Tipitapa. After discussions with DESAPER, it was decided to locate the pilot project in Nandaime.

Subsequent to the successful initiation of the pilot project, an additional U.S. $8000 was provided to expedite its evaluation and continue research into the IOSSP technology.

4.0 Objectives of Pilot Project

The objectives of the pilot project were to establish a water quality testing laboratory at the hospital in Nandaime, a small city located approximately 65 km southeast of Managua, and field test the performance of the IOSSP household water treatment units at selected locations in the surrounding rural community. The laboratory was needed to support the field research.

5.0 Project Plan

Hospital Rommel Carrasquilla, located in Nandaime was visited March 1 -5, 1993 to meet the hospital director and other interested personnel involved either directly or indirectly with

D~APER. An assessment of local laboratory and field-testing requirements and potential sites for the location of the household water filters were identified.

Both the INAA and MINSA regional laboratories were willing to assist in the project. The INAA laboratory was selected because it was using the membrane filtration technique similar to that being located at the hospital. (The MINSA laboratory uses the multiple tube fermentation technique.)

An assessment was made of materials available to construct the filters. Adequate sand and gravel materials could be located in the Nandaime area and suitable containers, pipes, valves and other required supplies could be found in local hardware stores or those in Managua.

Local concrete building block factories were visited to evaluate their manufacturing skill level. This information was needed to design future inexpensive concrete versions of the household water filter.

6.0 Project Implementation

6.1 Laboratory

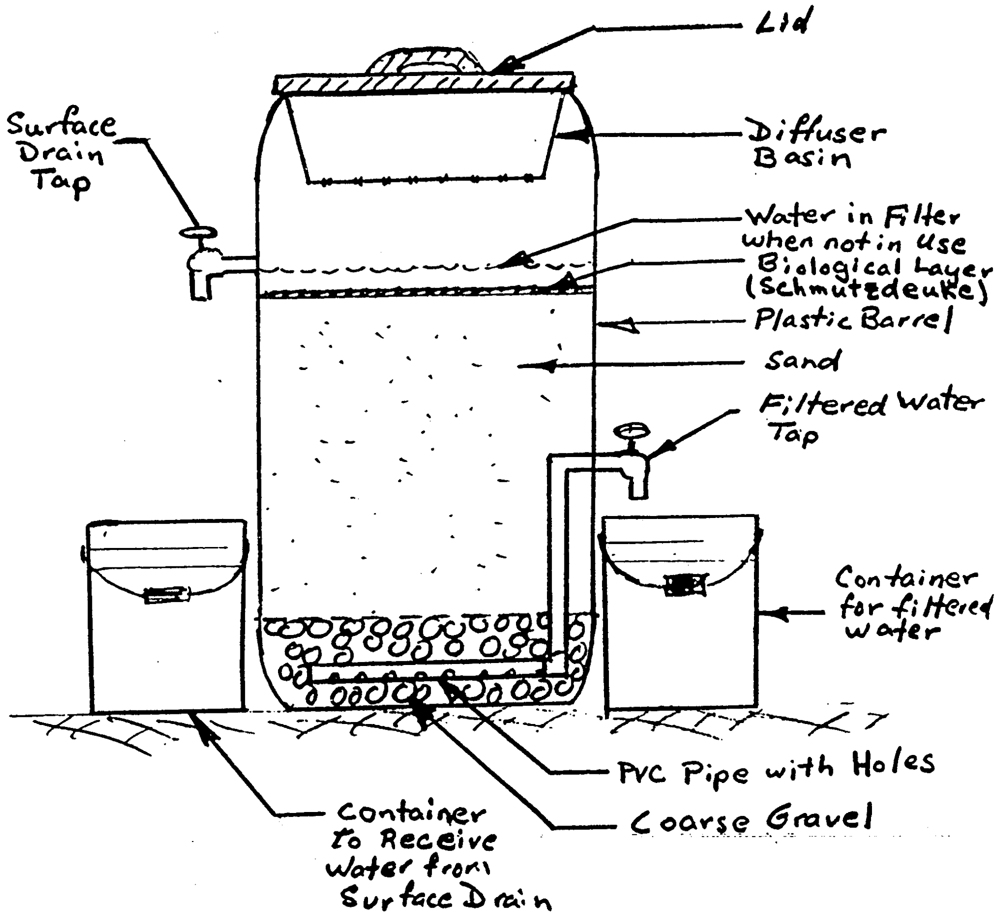
A portable incubator and supplies necessary to perform approximately 100 tests to quantify the concentration of faecal coliform bacteria using the membrane filter method were brought from the University of Calgary to the hospital in Nandaime May 10, 1993. During the first week the laboratory was established and six hospital staff were trained in the laboratory use and procedures for taking samples of water. The Chief of the INAA Water Quality Control Laboratory, Region IV, located in Granada acted as a resource person to the hospital staff during the pilot project period. The laboratory equipment and supplies cost approximately U.S. $2800.

A copy of the laboratory equipment required and the detailed laboratory instructions and procedures may be found in Annex A.

6.2 Household water filter units

6.2.1 Design

The design of the intermittently operated household filter is shown on the following sketch. The filter consists of a cylindrical container approximately one meter in height and 40 cm in diameter (plastic barrel), a 10 cm layer of washed coarse gravel which surrounds a perforated drain pipe leading out of the filter container to a tap, a 50 cm layer of washed fine sand, a diffusing basin, surface drain and cover. The sand should have similar physical characteristics to that used in continuously operated slow sand filters; that is, effective size between 0.15 to 0.3 mm and uniformity coefficient less than 5 though <u>any local fine sand from a fairly clean source</u> could probably be used successfully. The tap is located such that a container to receive the treated water may be located below it. The surface drain is located approximately 5 cm above top of the sand. The diffusing basin must be large enough to cover at least 80 % of the sand surface. The bottom of the basin is perforated with holes approximately 2 mm in diameter and spaced 3 cm apart. All water poured into the filter must pass through the diffusing basin.



Sketch of:
Nicaragua Household
Slow Sand Filter.
(Plastic barrel version)

6.2.2 Operation

The household filter is operated by removing the cover and pouring water into the filter through the diffusing basin. The surface drain is closed and the tap should be open. Once all water required has been filtered and captured in a clean container below the tap, the tap is closed and the surface drain is opened to drain off any excess. <u>It is very important that a layer of water remain on the surface of the filter.</u> After approximately 2 weeks of proper operation, (longer if coarser sand is used), faecal coliform removal rates in excess of 99 % can be expected. If the filter rate decreases below acceptable levels it is necessary to remove the biological layer on the filter surface and 1 cm of the surface sand. The sand may be replenished immediately or after a second or third cleaning. The filter performance will not be affected for more than one day after cleaning. As the filtration rate decreases the quality of the filtered water improves.

6.2.3 Installation

During the second week of the visit, four household IOSSF units were constructed at the hospital in Nandaime using materials purchased in Nandaime, Managua or gathered locally, (as in the case of the sand and gravel). Three of the filters were located in households in the surrounding rural area and one at the hospital in Nandaime. The households were trained in filter use. The fourth filter was located on the hospital grounds. Since Nandaime has a chlorinated but "suspect" water supply it was necessary to dechlorinate the water by allowing it to breath for twenty-four hours before pouring it through the filter; otherwise, the biological layer in the filter responsible for the pathogen removal may be damaged or destroyed.

Each of the plastic barrel household water filters cost approximately U.S. $75. It was understood from the beginning that these filters were too expensive for most rural households and that less expensive models needed to be designed. However, the objectives of this pilot project were to evaluate the technology and filter acceptance. As noted later in this report an inexpensive filter design suitable for rural Nicaragua was developed. The concrete design could not be used because of the rapid pace the project was implemented.

The pilot project was to last approximately 8 to 10 weeks. The performance of each of the filters was monitored once a week by hospital staff and the Chief of the INAA Water Quality Control Laboratory in Granada. At the same time the operation of the filters were monitored and additional training in filter use was provided as required. Maintenance to the filters was performed if needed.

7.0 Results and Conclusions

The laboratory and households, where the water filters were installed, were visited by University of Calgary and PAHO (Nica) consultants during the week of July 26- 31, 1993.

7.1 Laboratory

All six of the hospital staff successfully used the portable laboratory until supplies to support it ran out. This conclusion is based on anecdotal evidence and a comparison of laboratory analyses performed by the hospital staff and those obtained by the INAA Water Quality Control Laboratory in Granada. .

7.2 Filters

The filters all performed very well. After a few weeks ensuring that the households were operating them correctly and allowing for development of the filters' bacteria removal potential the filters were each removing 99% or more of the faecal coliform bacteria from the water. The performance of the filters after two months of operation ire summarized in the following table:

Table I. Performance of household water filters.

Site	Quality of Influent Water Faecal coliform bacteria/100 ml	Quality of Filtered Water Faecal coliform bacteria/100 ml	Removal Efficiency Per cent
El Manchon (well)	5000	47	99.1
Las Conchitas (well)	4300	10	99.8
Monte Grande (well)	7000	27	99.6
Hospital (Distribution system)	0	0	n/a

Interviews with hospital staff, who participated in the project and the Chief of the INAA Water Quality Control Laboratory in Granada, indicated that the filters were well accepted in each of the households, a factor which definitely contributed to their success.

Householders reported that the bacteriologically filtered water looked and tasted better. Also, since the householders started using the water, none of the members of the household had experienced any gastrointestinal disorders. These positive experiences convinced other nearby households to use the water filters to treat their drinking water.

7.3 Filter design

Based on experience with household water filters in Nicaragua and an assessment of local concrete product manufacturing capabilities, a low cost concrete household water future was designed and tested at the University of Calgary, Canada. This design and results of its performance evaluation are presented in Annex B. The concrete household water filter can be manufactured in Nicaragua for approximately U.S. $25.

8.0 Household Water Filter Project -Phase Two

8.1 Objectives

The general objective of phase two of the household water filter project is to further develop IOSSF technology for improving the health and quality of life of the rural people of Nicaragua through provision of safe water supplies.

The specific objectives of this project are as follows:

1. Evaluate the technical performance of IOSSF technology in rural communities in Nicaragua.

2. Evaluate community acceptance of IOSSF technology.

3. Evaluate the impact of IOSSF technology on community health and quality of life.

4. Based on results of objectives 1, 2, and 3, formulate recommendations regarding the use of IOSSF technology in rural communities in Nicaragua.

5. Train Nicaraguan professionals and technicians in IOSSF technology and technical development methods.

6. Strengthen Nicaraguan and Canadian Universities in their capacity to investigate, evaluate and teach water and sanitation technology.

8.2 Activities

8.2.1 Filter Installation in Communities

One or more community would be selected for evaluating filter use. At least 30 households, appropriately trained, would use the filter in each community. Filter performance, design and acceptance would be monitored. Group interaction among filter users would be encouraged. Filter design and operation modifications would be recorded and immediately implemented where practical.

8.2.2 Sanitation Education

Individual households and communities participating in the water filter project would be provided basic sanitation education over the duration of the project.

8.3 Technology Development

8.3.1 Filter technology

The objective of this activity would be to develop design criteria for filter construction and operation. Research would consist of:

I. Determining the relationship between filter design parameters such as: type of sand, depth of sand, depth of water above sand, design and location of diffusing plate or basin, method of introducing water into filter and possible use of geomembranes on filter surface and filter performance as measured by the efficiency of removal of faecal coliform bacteria.

2. Determine the relationship between the characteristics of filter operation and filter performance. Questions such as frequency of operation, volume of water filtered per operation and duration of operation would be examined.

3. Develop and test different filter design concepts. Examples include: -household filter
-Large scale or community filter
-Operations combined with photovoltaic energy supply and pumps -filter operations combined with hand pumps (e.g. chain pumps)

Various materials, methods of construction, methods of operation and water supply (rivers, lakes and wells) would be considered. Results from this investigation would be used to further improve and develop techniques used in activities 8.1 and 8.2.

4. Develop and evaluate methods for treating very turbid water from rivers and streams.

8.3.2 Evaluation of the performance of IOSSF in terms of its ability to remove cholera from water.

The objective would be to directly measure the ability of IOSSF technology to remove cholera from water. This type of investigation requires laboratory conditions and techniques normally found in clinical laboratories specifically designed for this purpose. Results from this investigation would be used to further improve and develop techniques used in activities 8.1 and 8.2.

8.3.3 Evaluation of the impact of the use of IOSSF technology on individual households and the community

The objective would be to investigate the impact of the use of IOSSF technology in the individual households and the community considering: -sanitation conditions, -health conditions and socio-cultural aspects (quality of life).
It is hoped that each of these aspects could be examined prior to or very soon after filter installation. The monitoring and evaluation would continue for the duration of the project. Wherever possible improvements (or negative effects) in quality of life, directly or indirectly attributable to filter use, would be observed and documented. Results from these studies would be used to further develop and improve techniques used in activities 8.1 and 8.2.

8.3.4 Sanitation education

Sanitation education techniques would be identified, developed and evaluated in an effort to support activity 8.2.

8.4 Training and Technology Transfer

Project participants would be provided the opportunity to attend workshops, courses, seminars, conferences, symposiums, and technical visits, within and outside Nicaragua and Canada, to support activities 8.1, 8.2 and 8.3.

Efforts would be made to build a reference library on the technologies and methods used or developed by the project.

Technology transfer would be further encouraged by facilitating the publication of all of the project experiences in both Spanish and English.

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