FAILURES AND PROBLEMS OF RURAL DISINFECTION

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ABSTRACT

This paper reports that in recent decades, the number of communities with water supply systems has increased significantly in the Region of Latin America and the Caribbean and that most of the national plans emphasize water availability and coverage. However, the need for disinfection and the adequate maintenance of disinfection systems to supply safe water to rural communities has not received the same attention.

Disinfection has been practiced since the beginning of the 20th century, but for several reasons it has been limited and inefficient in rural communities. This document analyzes the causes of this inefficiency from the sociocultural, technical, political, institutional, legal, and economic perspectives. Because of inefficient disinfection, many people in the Region’s rural areas are exposed to water-related health risks.

1. Introduction

The disinfection of drinking water is the last barrier against water-borne pathogens, and in rural communities it is often the only barrier against contamination. However, disinfection is not sufficient to guarantee good health since pathogens may be transmitted via other routes, such as food, receiving bodies contaminated with wastewater, person-to-person contact and contact with animals.

At the symposium on water quality in Latin America and the Caribbean, held in Buenos Aires in 1994, one of the conclusions was that the water received in almost 40% of households in the Region has been either inadequately disinfected or not disinfected at all.

Disinfection programs were set up in response to the 1991 cholera epidemic, the seventh pandemic in Latin America; however, since this was an emergency situation, many countries did not continue with these programs.
In August and September 1994, the Division of Health and Environment of the Pan American Health Organization conducted a rapid assessment of water disinfection systems in Latin America and the Caribbean. Of the 23 countries that replied to the survey, only 17 provided adequate data. Based on the information obtained, it can be asserted that more than 91 million people receive water without disinfection or with inadequate disinfection (PAHO, 1994). (4, 10)

Subsequently, at the meeting of environment experts at the Summit of the Americas, held in Puerto Rico in 1995, water quality was considered an essential element for the so-called “Alliance for the Prevention of Pollution”. At that meeting a series of actions were proposed for the setting up of cooperation projects, including a project on chlorination, since chlorination is the minimum disinfection method that should be adopted by the countries of the Region. (7)

At the Regional Meeting on the Quality of Drinking Water, held in May 1996, in Lima, Peru, a ten-year plan for improving the quality of drinking water in Latin America and the Caribbean was proposed. However, despite the efforts made, people continue to distrust tap water and do not drink water directly from the taps in either urban or rural areas of the countries. There are no reliable statistical data in the Region on the percentage of the rural population that has access to safe water; PAHO believes this figure to be quite low. (7)

This paper identifies the main problems and obstacles encountered in rural disinfection programs, and discusses sociocultural, technical, political, institutional, economic and sustainability aspects, among others.

2. Disinfection technology

Chlorination using chlorine gas is one of the main technologies used in Latin America and the Caribbean; approximately 82% of those who receive disinfected water are benefited with this procedure (10). Gas chlorination is applied in the final stage of the treatment process in most water treatment plants, including wells that feed storage tanks connected directly to water distribution systems. This type of disinfection is also used in medium and small municipalities.

Another technology is the application of hypochlorite; it is estimated that almost 17% of the population receive water disinfected by hypochlorination. Hypochlorite is commercially available in the form of sodium hypochlorite solution (concentration ranging from 3% to 10%) or it can be generated in situ by exposing a sodium chloride solution to electrolysis to obtain a concentration between 0.4 and 1%. A hypochlorite solution can also be prepared from calcium hypochlorite compounds or chlorinated lime.
The most common way of feeding hypochlorite solutions is with a positive displacement pump, Venturi pipe, submerged orifices, or equipment constructed on-site. Another form of hypochlorination is with calcium hypochlorite tablets that dissolve rapidly.

Boiling is the most common water disinfection method at the domestic level and it is recommended in emergencies. This method is easy to understand and simple to implement; however, it is expensive and does not protect against recontamination. Care should be taken, therefore, to avoid the recontamination caused by dirty hands, containers, or utensils. (6)

There are other disinfection methods that together do not represent more than 1%, including ozonation, the use of chlorine dioxide, ultraviolet light, and a mixing of oxidants.

3. Causes of inadequate disinfection

In recent years, PAHO has carried out several research studies to determine the reasons behind the failure to disinfect rural water systems in Latin America and the Caribbean. The reasons are analyzed in the following paragraphs:

3.1 Sociocultural causes

The introduction of disinfection systems in rural communities does not consist merely of installing and applying simple engineering techniques. It is an introduction of a foreign element into the community that implies a significant change, and sociocultural and educational factors must be taken into account.

The local culture should receive special attention since it determines many aspects of human behavior, such as the social importance given to different roles in the community, and what is considered proper behavior for the individual and the group. In many cultures, for instance, elderly people traditionally hold authority and wield their influence in family and community matters.

Culture molds the way people interpret and evaluate their environment. Some societies conceive the physical environment as a provider of resources for curative and preventive medicine, or as a cause of diseases; some even ascribe a social and spiritual dimension to their physical environment. (3) It is necessary to understand how communities and families function and what factors promote changes.

Traditionally, rural communities are assumed to be in a state of extreme poverty and to possess a minimal capacity for participating in these water system projects; all they are asked to contribute is unskilled labor and local building materials. In actual fact,
the money and time available vary from one family to another, and each family has its own priorities.

A project of this type must be managed as an economic and social asset, and the community should participate actively and make decisions at the different project stages.

Over time, societies undergo a readjustment in their social and cultural structure. Such a process can be the result of contact with other societies or it can be caused by the alteration of the local environment.\(^{(3)}\)

The decision to accept a technology rather than rejecting it is based on the characteristics of the individual and the family, and in particular on the participation of women and the group; it depends, also, on the physical environment and the social, economic, cultural and demographic contexts.

Access to education can help people understand the health-related advantages of applying new disinfection techniques.

In some cases, influential leaders can persuade the community to accept the technology, emphasizing the social prestige of installing disinfection equipment and its benefits for the health of the community. In other cases, there can be disagreement among community leaders; or those with traditional authority may be afraid of losing their power and social status, and for this reason they oppose innovations.

It is important to analyze the role and behavioral pattern of individuals and social groups within the community. People resist changes for many reasons; they may feel resentment against foreign experts who are unfamiliar with local customs and they sometimes think that these foreigners benefit more from the technology than the local population itself.

Another aspect that is usually neglected is the time or season of the year. For example, whether or not the installation of the new system coincides with the agricultural season will be a determining factor for local acceptance or rejection.

The community should be motivated and educated using simple language through different mass media to persuade them to participate in the project, creating in them a sense of ownership and political commitment to ensure the success of the project. The regional plan for the improvement of water quality thus includes education, social mobilization, and self-sustainability.\(^{(7)}\)

The motivation and education of the community should not be applied vertically with a top-down approach; in such a situation the active role corresponds to the high decision-making levels and specialized technicians who design the programs that will subsequently be delivered to the communities for them to operate and maintain.
It should be noted that the sociocultural performance of the communities forming part of pilot experiences cannot be extrapolated to other areas unless similar conditions exist there. \(^{(1)}\)

### 3.2 Institutional causes

Many countries of the Region have redefined their policies on water and sanitation and have implemented decentralization reforms in the sector to enhance local government action. In rural areas, however, these reforms in water supply and disinfection have not produced the expected benefits.\(^{(2)}\)

Decentralization and the assigning of more responsibilities to local government are being increasingly applied in Latin America and the Caribbean. Public pressure to obtain better services, the rapid growth of cities, willingness to assign responsibilities to the lower government levels, economic reform, and the democratization process are all factors that have boosted these efforts.

Three types of decentralization schemes are being applied in the water supply and sanitation sector, and they have a significant effect on rural services.

Devolution is the transfer of authority and decision-making to local governments, either regional or municipal. Many cities operate their own companies with a high degree of autonomy, while others are excessively controlled by municipal governments. In some cases, local governments have signed concession contracts authorizing private companies to operate water systems. Buenos Aires and Mexico City are well-known examples. However, this model does not include the delivery of services in rural areas. Householders in most rural areas do not pay taxes or do not have the payment capacity to cover capital and ordinary costs. Hence, rural areas are not receiving the required attention, and should be regarded as a priority.

Deconcentration includes several types of administrative arrangements whereby resources and staff are assigned at regional levels within the same organization. Central government organizations (ministries of health) used to operate through regional or provincial offices. The key factor in this type of decentralization is that the regional offices have operational autonomy. Many central organizations have not yet delegated such autonomy.\(^{(12)}\)
Finally, delegation is the assignment of duties and responsibilities to a substitute or concessionaire unit. This model is found in Chile, where all responsibilities for water supply in rural and urban areas were delegated to regional water companies in 1991. The country was divided into 12 geographical areas with a different company in each area. Other examples are Brazil and the SANAA in Honduras. In practice, this model works in countries with a higher level of development. In countries where there are large poor populations in rural areas, such a responsibility would be too great for most companies to handle. Generally speaking, Central America lags behind the other countries of the Region in its reform efforts (12).

In most Latin American countries the central organization proves inefficient in its management and administration of water systems and disinfection projects in rural areas. Another factor is dependence on financing from donor agencies. International and national NGOs have played a key role in community promotion and training activities and the provision of technical assistance to enable communities to manage their own projects. Finally, the presence of several different agencies has led to the application of contradictory approaches.

In many countries, rural water supply systems are managed by legally constituted community councils or administrative boards.

As a general rule, the countries of the Region lack the adequate institutional infrastructure to assume the responsibility of promoting disinfection, storage, control, monitoring, and safe management of water in rural communities.

3.3 Technical causes

Many studies have confirmed a reduction in pediatric diarrhoea in areas with adequate concentrations of residual chlorine in water distribution systems (Macedo 1993, Universidad del Valle 1987, Bersh y Osorio 1985). For a variety of reasons, however, disinfection programs in rural communities of the Region are either deficient or non-existent.

Disinfection is a means to obtaining safe water, so it is essential to know the source and quality of the water to be disinfected. These aspects, however, are not taken into consideration in most cases.

WHO Guidelines for the Quality of Drinking Water (WHO 1995) recommend that the water to be disinfected should not have suspended matter and its turbidity should not be higher than 1 NTU nor exceed 5 NTU in any sample. Turbidity protects pathogens grouped around particles or adhered to them. (5)
When disinfection systems are applied, organic matter is not taken into consideration, nor reducing agents such as iron, manganese and hydrogen sulfide that react with the oxidants, and which make it necessary to increase the dosage to maintain an adequate residual. It is important to know the different physical, chemical and microbiological factors that influence effectiveness when selecting a disinfectant.

For proper water disinfection, the quality and effectiveness of the disinfectant must be taken into account. The disinfectant has to meet certain technical requirements, such as the ability to destroy or inactivate pathogens present in the water within a specific period of time.

Those responsible for applying disinfection programs know very little about the behavior of the different microorganisms that react in different ways to different disinfectants. Generally speaking, bacterial spores are more resistant than protozoa cysts and helminth eggs. The latter are more resistant than viruses, and viruses are more resistant than vegetative bacteria.

For example, a sufficient dose of chlorine, in gas or hypochlorite form, with a given contact time, is a good disinfectant to use against bacteria, viruses and some protozoa, but is not very effective for *Giardia* cysts at low temperatures. In the case of *Cryptosporidium* and helminth eggs, additional treatment may be necessary to eliminate them.

Ozone is more effective than chlorine, since it destroys any microorganism, including viruses and protozoa, but it does not provide a residual and its use requires electric energy and trained technical personnel. Ultraviolet radiation facilities have the advantage of working during long periods and can be handled by technicians with little training only, but they also need electric energy and do not leave a residual.\(^{14}\)

Programs fail to take into account the fact that the time required to destroy or inactivate microorganisms is proportional to the quantity originally present in the water source. In addition, water temperature and pH also affect both the survival of microorganisms and the effectiveness of the disinfectant.

Training, or at least complete information, on the different disinfectants used in water supply systems is not provided. The disinfectants should be easy to handle and apply and capable of maintaining residual concentrations in the distribution system as a protective measure against recontamination. In addition, the chlorine demand needs to be determined before application of the disinfectant.

The disinfectant should not produce or introduce toxic substances above WHO Guideline values nor modify water characteristics. Determination of the concentration of the disinfectant in the water should be sensitive, rapid and easy to carry out in the field and laboratory.
Some time ago, deficiencies in water disinfection in rural communities were solved using simple technologies involving only small investments. Up to 1974, the concern was how to make disinfection more efficient and how to achieve wider application in developing countries. Since 1974 these approaches began to change radically when it was discovered that chloroform and other trihalomethanes were produced during the chlorination of drinking water. More than 400 disinfection by-products (DBP) have been identified for chlorine and other chemical disinfectants. However, only a small number of these by-products have been properly assessed to determine whether they really constitute a threat for public health.\(^{11}\)

People’s fear of carcinogenic chemicals has reduced their interest in disinfection. There is considerable disproportion between the real facts and the public’s perception of health hazards associated with the disinfection of drinking water. With regard to DBP, the perceived risk is far higher than the real risk as verified to date. It should be noted that pathogens are still the leading cause of water-borne diseases and deaths throughout the Region.\(^{11}\)

It is very important for staff members and professionals at decision-making levels of water, environment, and health agencies to have complete, up-to-date information on disinfection by-products and their implications for health, as well as on water-borne pathogens. International organizations should continue their co-operation to guarantee the dissemination of this information.

Another typical feature of disinfection programs is that there are no connected programs available for operation, maintenance or administrative support. When selecting a disinfection system, the promoters must bear in mind the conditions in the community and the technical skills of those who will be in charge of running and maintaining the system. Ongoing training and technical assistance programs should be set in place.

One way to ensure reliable, effective, and sustainable disinfection is to provide an effective operation, maintenance and repair program. It should be noted that the lack of financial resources has a negative influence on operation and maintenance programs.

Another aspect not taken into consideration is that the installation of disinfection systems should be linked to follow-up control programs to monitor the quality of the drinking water delivered to the rural community. A minimum budget should be made available for laboratory implementation, assessment of the system’s efficiency and determination of bacteriological indicators of water quality.

**3.4 Financial policy**
If sustainability is to be achieved in water supply and disinfection projects, there must be a financial policy of shared costs, community participation through contributions of labor, material or cash, and financial contributions from public or private entities.\(^9\)

The failure of disinfection projects in rural areas has often been due to the fact that the communities have neither the organizational nor the financial capacity to manage these systems efficiently.

Usually, no one asks the community or users what services they want and are willing to pay for and maintain. When water supply projects are based on community demand, the sustainability of the project increases significantly.\(^9\) This should include supplying the families with adequate information, developing institutional capacities, and reorienting the supply agencies, in such a way that the consumer demand guides the programs.\(^13\)

Disinfection projects lack financing and there is not an adequate policy for the limited resources of the sector.

The global trend toward democratization coincides with the participation of the private sector to complement government services or provide alternative ones. It has been concluded that past efforts have not been successful and that governments cannot continue to cover the costs involved.

However, although in many countries the role of the private sector in supplying these services has increased, the hoped-for benefits in rural areas have not materialized. Many of these projects do not have financing for follow-up, evaluation, or sustainability.

There has been no promotion regarding financial policy in the communities, with the result that there is no commitment on the part of the community to pay a contribution to cover the project’s operational and maintenance expenses.

It is sometimes desirable to group the communities in a specific area to obtain scale economies, selecting such communities according to pre-established criteria. In this way, fixed direct and indirect costs are prorated among a larger number of beneficiaries.

### 3.5 Legal framework

There exists a legal and institutional gap in the water supply and basic sanitation sector in rural areas.
Different organizations carry out their development activities, applying different financing policies, often with only vague legal bases. Sometimes such organizations “overlap”, duplicating efforts in the same areas.

There are laws stating that provincial municipalities are responsible for providing the services in the entire province; however, municipalities have not taken responsibility for the services and they remain without technical, administrative, or commercial orientation.

3.6 Monitoring

Programs for the control and monitoring of water quality in rural areas have not been applied continuously. In those places where such programs have been used, they have deteriorated because of the weakening of the health agencies responsible for them. In addition, the installation of disinfection systems has not been linked with a program for the control and monitoring of water quality.

There is a lack of awareness and knowledge concerning the need for programs to control and monitor water quality, and the great importance of such programs, both at the political decision-making levels and in the community itself.

Control and monitoring programs are set up for the purpose of detecting, predicting, and preventing contamination to minimize the incidence of water-borne diseases.

The application of these programs will improve the service since it will ensure that the disinfection system is working satisfactorily and conforming to water quality standards.

To implement these programs, minimum laboratories are required to carry out the analysis of residual chlorine, bacteriological quality indicators, turbidity, pH, and sanitary inspection. The implementation of other parameters will depend on the quality of the water to be treated.

Another aspect to consider is the training of the staff in charge of these programs. Training topics should include: sampling methodologies, analytical determinations, updating of surveys for sanitary inspections and the development of data processing systems.

An effective program for the control and monitoring of water quality with an emphasis on the measurement of residual chlorine and bacteriological quality indicators can provide immediate warning of pollution. Resources for such programs, however, are not available.
Innovative mechanisms for control and monitoring programs are not being promoted in each country as they should be if a regional plan is to be set up. The need to establish a national plan is a political and technical justification to show that the country has commitments with the health of its population.

For the application of control and monitoring programs, countries should have well-defined methods and standards for the quality of their drinking water. They need to support each other to design programs and establish common instruments such as laboratory networks and technology and information systems.

The participation and technical assistance of international agencies are essential to incorporate the concept of water quality into investment programs and to support the development of multi-sector methods relating to planning, technological adaptation, training and financing.

One of the components proposed in the regional plan for the improvement of the quality of drinking water is the monitoring and control of water quality. This component includes techniques for sampling and analyses, sanitary inspections, accreditation and intercalibration of laboratories, analytical quality assurance and control, an information system, and epidemiological surveillance.

CEPIS was proposed as the regional coordinating center for water quality control and monitoring programs.

3.7 Training

The selection of appropriate disinfection technologies calls for training programs at different levels: for staff members, professionals, technicians, operators and the community.

The training programs applied are usually deficient, lacking in continuity or follow-up. Training mechanisms are not promoted as they should be, through motivation, publicity or raising the awareness of the population on the importance of applying sanitary measures. Neither the health authorities nor the population at large have a real understanding of the connection between health problems and water quality.

This training should be linked with a political and social commitment to ensure its continuity. Training should be institutionalized and regarded as a continuous and permanent activity.

Efficient training programs are not promoted. Usually, a course is organized to teach all participants how to play their role within a project. However, this teaching by itself cannot solve the problems, for example, of installation, operation and maintenance of disinfection systems.
In any training program, aptitudes, education levels, human resources management, and program follow-up are aspects to be considered.

For the training to produce the desired results, it should be systematically planned for professionals, technicians, artisans, foremen and the community in general.

Planning should consider the training needs of the area and should not be limited only to the installation and operation of the system, but should cover health and social factors, and operation and maintenance programs.

4. Recommendations

- Countries should seek simple technological solutions for water disinfection in rural areas, compatible with the economic resources available and the degree of community development.

- Disinfection programs in rural areas should be given priority status, taking into consideration the quality of the water to be disinfected, community characteristics, sociocultural, educational, political, institutional and financial aspects.

- Reforms and modernization in the management of water supply and sanitation systems have significantly affected service delivery in rural areas; more attention must now be given to less benefited areas since they lack economic resources and skilled labor.

- Local capacity should be created for managing these projects, considering them as an economic and social asset, and the beneficiary community should participate actively and make decisions at the different stages of the project.

- Both institutional and community capacities should be strengthened with regard to reforms and modernization of the management of water supply and sanitation systems in rural areas.

- Each country should use new strategies to initiate or reactivate programs for the control and monitoring of water quality in rural areas. Such programs can be implemented progressively until they reach the desired level. They should include minimum laboratory equipment, training in chlorination, analytical methodologies, sampling, and data processing.

5. References


FRANCEYS, R; PICKFORD, John; REED, R. OMS (1994). Guía para el desarrollo del saneamiento in situ.


UNDP; World Bank; KATZ, Travis; SARA, Jennifer (1998). La sostenibilidad en el abastecimiento de agua en áreas rurales: recomendación de un estudio global.


WHO (1993). La desinfección del agua a nivel casero en zonas urbanas, marginales y rurales.

WHO (1997). Marco de la referencia para el plan regional estratégico para el mejoramiento de la calidad del agua potable.