COMMUNITY PARTICIPATION: A STRATEGY TO ACHIEVE LOW-RISK MICROBIOLOGICAL WATER AND EFFECTIVE DISINFECTION

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ABSTRACT

This document discusses the problems of adequate water supply services in rural areas and small municipalities. The main problem is basically associated with the approach used in the sector, where communities have been included only in the construction phase of the works. Several experiences shared and lessons learned from the “Joint Learning Projects” strategy have led to a modification of this approach. The active and decisive participation of the community at all stages of the projects and continuous institutional support have made possible the operation and sustainable use of water supply systems and, in particular, the use of a technological alternative such as the multiple stage filtration, MSF, which produces water with low microbiological risk and facilitates the application of effective disinfection.

1. Introduction

In Colombia, as in most Latin American countries, the main problems relating to an adequate provision of drinking water and sanitation services focus on small municipalities and rural areas. This situation was expected to improve with the decentralization process, where local authorities were made responsible for delivering these services. After several years, however, experiences show that limitations and deficiencies continue not only to affect the sustainability of investments and contributions made, but also to pose a health hazard to communities because of the poor microbiological quality of the water supply. A series of examples from the Andean area illustrate this situation:

In Ecuador: A participatory evaluation carried out in 40 water supply systems located in the rural area of eight provinces showed that 17 systems had treatment
plants with operation and maintenance problems. In addition, the treatment barriers were not in accordance with health hazards existing in the microbasins. Thirty of the systems had disinfection infrastructure, but 21 of these (70%) were not working (Visscher et al. 1996).

In the province of Azuay, in the southern part of the country, Ordóñez (1992) indicates that an evaluation of small drinking water treatment plants revealed that the process most deficient in terms of design, implementation, operation, maintenance and continuity was the disinfection process. In all the systems assessed, both the point of application of the disinfectant and the contact time were improper. Moreover, doses applied with regard to demand were usually set by the operator, without any type of control and without considering flow variations or variations in the quality of the influent.

**In Bolivia:** A participatory evaluation of 15 rural water systems in the departments of Chuquisaca, Cochabamba, and La Paz revealed that only three localities (20%) possessed treatment systems; ten had no disinfection system at all; four had infrastructure, but disinfection was inadequate; and only one system was working properly and guaranteed effective disinfection (Quiroga et al. 1997).

At the Workshop of Alternative Disinfection Technologies held in the city of Cochabamba, in 1997, Coronado and Menda (1997) reported that it was impossible to chlorinate water without losing disinfectant unless skilled labor was used, because of deficiencies in technical, operational and maintenance aspects. Another difficulty mentioned was that of using imported chlorinating equipment because it was expensive and not appropriate for the conditions and capacity of the rural communities.

**In Peru:** Based on an evaluation of small treatment systems, Lloyd and Helmer (1991) reported that 100% of such systems were not supplying water according to WHO guidelines. It has been recognized that the abandonment of chlorination practices due to fear raised by the presence of disinfection by-products, was one of the factors with the greatest incidence in the cholera pandemic. In this context, PAHO has recommended that under no circumstances should the practice of disinfection be abandoned (Otterstetter and Craun, 1997).

**In Colombia:** According to the Ministry of Health (1992), only 62% of the population of urban areas and 10% in rural areas received water suitable for human consumption. This situation reflected the condition of the water treatment infrastructure. According to information from the Ministries of Health and Development, of 1,050 municipalities for which there were data, only 630 (60%) possessed treatment plants. Of the 630 plants, 440 (70%) were working, but only 130 of these (corresponding to large and medium-sized cities) were working properly (Figure 1).
The situation at the national level was clearly related to the situation in each department. In Boyacá, the Health Secretariat in a 1997 study reported that of 55 municipalities (of a total of 124), with 28 urban treatment plants, only 20 were working and of these only 12 were working properly (Figure 2).

Based on studies carried out by PAHO/WHO between 1982 and 1995, as well as an assessment done in 20 countries of Latin America and the Caribbean in 1997, Reiff...
(1998) points out that the situation of reliably disinfected water supplies had improved in the large cities. However, it is evident that in rural areas disinfection problems are still critical, because of a series of factors:

- Insufficient motivation and commitment on the part of the communities to maintain continuous and reliable disinfection.
- Inadequate understanding and awareness of the importance of water disinfection.
- Low priority accorded to the financing of water disinfection.

Although these factors are important and affect the situation, they are clearly the result of underlying causes associated with the approaches used in the sector. Actions have traditionally focused on works, without considering the need for promoting people-centered comprehensive projects rather than projects targeting things.

2. Community participation approaches in the sector

The sector has adopted a technical and supply approach where community participation has sought basically the contribution of the population with labor and materials to reduce construction costs or to cover lack of resources. A criterion that sustains this approach assumes that people perceive the system as their own when they have built it themselves. However, once the infrastructure works have been completed, enthusiasm usually wanes, since according to Abbot (1996), when a problem is considered solved, the conflict that motivated the different agents to team up is over and the interest of the users of the project is reduced.

Community participation has also aimed at obtaining resources to finance the operation and maintenance costs, hence the activity of the Water Boards has focused on the collection of water rates to sustain the functioning of the system. Therefore, institutions want to establish a community organization to administrate the system once the construction works are finished; but the institutions fail to consider many aspects of the community organization: its representation, form of constitution or operation as a company providing services with quality criteria and economic and environmental efficiency.

In many cases, not even the above concepts are present, since it is assumed that participation exists when an initial visit is carried out to gather information on the execution of a project that has been generated by the institutions. Thus, the technology to be used and the level of service to be provided is decided externally and unilaterally, without the communities having the possibility to choose based on clear and precise information on the responsibilities and costs they would have to assume for the adequate operation, maintenance, and administration of the infrastructure. As a result, the community perceives the institutions to be the only agents responsible for the project, before, during and after the works. There is no
participatory process to consolidate the sense of ownership, and to strengthen in the communities the knowledge, skills, and abilities they need to manage their systems with sustainable criteria.

Ordóñez (1992) points out that in Ecuador, in the stages of design, construction, operation, and maintenance of small water supply systems, the usual procedure has been the following:

- Studies and designs are carried out by institutions in their own technical departments or by contract with private companies.
- The beneficiary community contributes non-skilled labor through the system of "mingas" (collective work) on Saturdays, Sundays and holidays.
- Institutions are in charge of the technical direction, supply of materials and skilled labor. The close relationship between the community and the executing entities ends practically the same day that the system is inaugurated and officially delivered to the community.

“The indicated system, totally plausible in its intention, has not given satisfactory results in practice for several reasons, and negative aspects have directly affected the quality of the water distributed”.

3. **Community participation in a new project cycle**

Bearing in mind the principles of Dublin (1992)⁴, the demand-based approach has been promoted. According to Khan and Wakeman (1998) this means "letting the needs of the community and their willingness to pay determine the main decisions concerning investment, because a system will only be sustainable if the community needs it enough to assume its maintenance. A project is more or less based on the demand in the measure in which the users propose options and commit themselves to providing resources to finance them".

The demand approach implies that the communities themselves select the technology and level of service they require. Thus, users’ knowledge of the geographical characteristics and water resources of their region, together with information provided by the institutions on the different technological alternatives with their respective costs, including environmental costs, should facilitate the community’s decision regarding the option most suitable to the community’s management capacity and willingness to pay for the service delivered.

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⁴a) water is an economic and social good; b) water management should be focused on the lowest level possible; c) integrated management should be applied to water resources; and d) women should play a fundamental role in water management.
This approach implies shifting decision-making capacity from the institutional levels to the community levels. Accordingly, to adapt effectively the demand-based approach, it is necessary to reconsider how the project cycle has been defined in the sector and the way in which active and decisive community participation can be made possible in each one of its different phases, in a process of co-operation with the institutions.

In Colombia, as illustrated in Figure 3, the sector's institutions have traditionally managed a project cycle ending with the conclusion of the works and delivery to the communities for operation and maintenance, basically seeking to meet institutional goals. As Valencia et al. (1998) point out, financing agencies and many technical institutions are interested only in the physical infrastructure and efficiency with which the resources are executed, regardless of whether they really solve the problems faced by the potential users of the systems.

However, within the framework of decentralization of functions and responsibilities developed in Colombia, as well as in other countries of Latin America, there is room for improvement in the quality of decision-making, sector efficiency, and business performance in the planning and implementation of projects and programs of the sector. (Okun et al. 1991).

In this context, and within the development of the Program for Sustainability of Water Supply and Sanitation Systems in Colombia (Ministry of Development; FINDETER; Cinara, 1998), a change in the approaches has been promoted and one essential aspect is the proposal of a new project cycle, which is continuous and establishes new actions to reach institutional and community objectives. Figure 4 shows the new project cycle proposed for the sector. It should be noted that it includes a resource management phase, usually at the local level; the administration, operation, and maintenance, also at the local level; and monitoring at every stage, which should
involve the various community and institutional actors at the municipal, departmental and national levels.

However, to promote and facilitate community participation in all phases of the project cycle, it should be taken into consideration that this cycle:

- demands a systematic process and not only the execution of specific activities.
- arises from inside the communities, based on joint efforts to solve common problems, which implies working out their internal conflicts.
- is directed toward community self-management and autonomy vis-a-vis the supporting institutions with whom the community has to negotiate.
- is an essential part of participation processes to boost the capacity of the communities to make their own decisions autonomously and develop their creativity to face the challenges of daily life.

The proposal emphasizes a comprehensive concept of participation, where the community thinks, acts, and decides as user of a system to which the population is entitled without ethnic, class or gender distinctions, and is responsible for maintaining it because it responds to community demands and has not been imposed by external decisions.

In this setting, conditions are created for the strengthening of community and municipal management, where the community and local governments not only assume the management and operation of the system, but also the control, authority, responsibility and projection of the service delivered. Following this logic, these agents should be enabled to organize, to take decisions and to manage organizational, technological, financial and human resources, regarding the provision of drinking water and sanitation services to create the conditions required to improve sustainability.
4. Promising experiences

In some rural areas of Colombia, projects have been implemented on a real scale, and a learning process has been introduced with the objective of validating, adapting, and developing a methodology to achieve sustainability of the systems with active community participation. This proposal, promoted by the Instituto Cinara, known as “joint learning projects” (Galvis et al. 1996; García et al. 1997; Restrepo et al. 1997), has increased, strengthened and optimized the institutional and community capacities to address development problems. This is understood as a process of permanent consensus-building, in which all actors contribute, learn and benefit, based on joint efforts among institutions, sectors and disciplines and community participation.

Below, we describe some preliminary experiences in rural localities. These have been pioneering experiences in drinking water improvement using the technology of multiple stage filtration (MSF) and disinfection. They are highly relevant to the objectives of this document.

4.1 The case of Ceylan

Ceylán is in the municipality of Bugalagrande, at the central part of the department of Valle del Cauca in the western mountain range, at 1,350 meters above sea level. It
has a mean temperature of 20 °C. The population is 3,000. The main economic activity is agriculture, and the principal product is coffee. It has three elementary schools, a high school oriented toward agriculture and a health care center. The supply system receives water from a surface source.

In 1989, with the support of the departmental government, the Committee of Coffee Producers of Valle, and the participation of Cinara, the treatment plant was built to use multiple stage filtration, MSF. As shown in Table 1, it had four units of upflow coarse filtration in series and two units of slow sand filtration. The optimized water supply system had the following components: intake; sand trap; conduit; treatment plant; disinfection system; storage tank and distribution network. The design flow was 9.6 liters per second.

The involvement of the users at the different stages of the project was gradual. Although the decision regarding the water treatment technology was made by the leaders only, it must be emphasized that during the development of the project, participants became more numerous and better informed. At the beginning there was more participation of women, who felt themselves more affected by water quality, especially in relation to their children’s diseases. At a second stage, the men organized themselves and carried out the negotiations with the institutions. Later on, in the upgrading of the distribution system, carried out with the support of an NGO (International Plan), the whole community became involved.

Table 1. General characteristics of the treatment plant of Ceylán

<table>
<thead>
<tr>
<th>Parameter/treatment barrier</th>
<th>Coarse filtration</th>
<th>Slow sand filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of flow</td>
<td>Upflow</td>
<td>Downflow</td>
</tr>
<tr>
<td>Treatment units</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Filtration velocity (m/h)</td>
<td>0.75</td>
<td>0.14</td>
</tr>
<tr>
<td>Filter medium</td>
<td>Gravel size: 25-3 mm Bed length: 2.0 m</td>
<td>Effective size: 0.24 mm Bed height: 1.20 m</td>
</tr>
</tbody>
</table>

Source: Galvis et al. (1997)

During the construction process and with the implementation of the treatment system in 1990, the community organized the administrative unit, creating the Association of Public Service Users, SERVIPUBLICOS. The people elected their governing board, established rules and regulations and obtained legal recognition; they defined tariffs in line with the operation, maintenance and management costs of the system, and embarked on activities for the general improvement of local sanitary conditions.

After eight years of operation, the present situation of the service is the following: coverage stands at 98%; the system operates continuously 24 hours a day; by community decision at a general assembly of users, the installation of domestic meters was approved to rationalize water consumption and to fix a fair payment for
the service. There is a financial surplus to pay minor repair costs. The community is paying for the sewerage and refuse collection service, also managed by SERVIPUBLICOS. With regard to water quality, based on the monitoring carried out during more than six years by Cinara (Galvis et al. 1997), turbidity and true color parameters comply with the national sanitary legislation (Table 2). With reference to faecal coliforms, water presents a low microbiological risk that facilitates effective disinfection.

These aspects are certified monthly through analyses carried out by the Secretary of Health of the department of Valle. According to the register of daily consultations at the health care center, the leading causes of diseases for the rural area of the jurisdiction were diarrhoeal diseases due to amebiasis and parasites. According to the doctor and the nurse, after the implementation of the treatment plant, the incidence of diarrhoea in children was reduced and scabies, a common skin disease, almost disappeared.

Table 2. Results of water quality of the system of Ceylan

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Raw water</th>
<th>Coarse filters</th>
<th>Slow sand filters</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0.6 – 15</td>
<td>28</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.1 – 0.6</td>
<td>0.8</td>
<td>0.4</td>
<td>&lt; 5 NTU: 99%</td>
</tr>
<tr>
<td>True color (CU)</td>
<td>2 – 21</td>
<td>5.4</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 – 21</td>
<td>4.0</td>
<td>3.0</td>
<td>&lt; 15 CU: 100%</td>
</tr>
<tr>
<td>Faecal coliform (CFU/100 ml)</td>
<td>46 – 1920</td>
<td>332</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-382</td>
<td>50</td>
<td>1.0</td>
<td>&lt; 3 CFU/100 ml: 95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.24</td>
<td></td>
<td>&lt; 25 CFU/100 ml: 100%</td>
</tr>
</tbody>
</table>

N: number of cases
Source: Galvis et al. (1997)

On August 25, 1998, within the framework of the Community Management project supported by the IRC, International Water and Sanitation Center, and the program of Young Researchers supported by COLCIENCIAS, Carvajal (personal communication 1998) using “DelAgua” equipment, carried out a specific sampling of water quality, the results of which are shown in Table 3.

Table 3. Results of water quality sampling in the distribution network

<table>
<thead>
<tr>
<th>Sampling site/parameter</th>
<th>pH (units)</th>
<th>Residual chlorine (mg/L)</th>
<th>Faecal coliforms (CFU/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage tank outlet</td>
<td>7.4</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>Health care center</td>
<td>7.4</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>Household in the highest point of the network</td>
<td>7.4</td>
<td>0.2</td>
<td>4</td>
</tr>
<tr>
<td>Household in the farthest point of the network</td>
<td>7.4</td>
<td>0.4</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Carvajal (personal communication 1998)
As it can be noted, the household located at the highest point of the distribution network had very low residual chlorine and presence of faecal coliforms. Alerted to this situation, members of the administrative entity, with institutional support, carried out a sanitary household inspection and identified a point of recontamination, caused by broken sewerage piping and its inadequate connection with regard to the water supply system (too near). The situation has already been corrected.

4.2 The case of Mondomo

Mondomo is in the municipality of Santander de Quilichao at the north of the department of Cauca. It is located at 1,300 meters above sea level and has a mean temperature of 21 °C. The population is 3,300. The main economic activities are agriculture, livestock, and agroindustry. It has two high schools, two elementary schools and a health care center. The supply system works by gravity fed by a surface source.

Water supply problems, especially due to poor water quality and discontinuity, motivated community leaders to seek support to build a treatment plant and to undertake actions for the protection and conservation of the microbasin. As a result of the earthquake of 1994 that affected the locality, the community received support from national institutions such as FINDETER; from departmental institutions such as the Water Unit and the Health Secretariat of Cauca; from the municipality of Santander de Quilichao, as well as from private organizations such as the Propal Foundation, and a business group known as "Por un Valle solidario con el Cauca " ("Solidarity with the Cauca") and NGOs such as International Plan, and the Nasa Kiwe Foundation. Cinara participated as facilitator of the interaction process between the community and the institutions.

The community participated in the project planning and selected multiple stage filtration, MSF, as the more suitable alternative, because of its technical, economic and social conditions. The community also participated in the design of the treatment system and in the inspection of works. It contributed with labor, especially to optimize sections of the distribution network and household connections in poor conditions.

In August 1997, the construction of the treatment plant was finished and put into operation. The supply system had the following components: intake, sand trap, main line, treatment plant (including four dynamic filters, four upflow coarse filters in layers and four slow sand filters presented in Table 4), three storage tanks (one main tank and two pressure break tanks), the distribution network and domestic meters in every connected household. The design flow of the system was 18 liters per second.

While working on the construction, the community also participated actively in the creation of the Association of Users of the Water Supply System, in the election of its
Governing Board, study and approval of rules, regulation of users, socioeconomic stratification and user census, as well as in the census of hydraulic and sanitary household facilities in bad conditions.

Table 4. General characteristics of the treatment plant of Mondomo

<table>
<thead>
<tr>
<th>Parameter/treatment barrier</th>
<th>Dynamic filtration</th>
<th>Coarse filtration</th>
<th>Slow sand filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of flow</td>
<td>Downflow</td>
<td>Upflow</td>
<td>Downflow</td>
</tr>
<tr>
<td>Treatment units</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Filtration velocity (m/h)</td>
<td>3.0</td>
<td>0.75</td>
<td>0.15</td>
</tr>
<tr>
<td>Filter medium</td>
<td>Size: 25-6 mm</td>
<td>Size: 25-3 mm</td>
<td>Effective size: 0.18 mm</td>
</tr>
<tr>
<td></td>
<td>Bed length: 0.60 cm</td>
<td>Bed length: 1.20 m</td>
<td>Bed height: 1.0 m</td>
</tr>
</tbody>
</table>

Source: Cinara (1995)

After one year of operation, there is a coverage of 95%, the service is provided continuously 24 hours a day, and the quantity satisfies user needs. The tariffs increased and a socioeconomic stratification was established according to the Law 142 of 1994 for Public Household Services and the system sustainability. Arrears in the payment of water rates stand at less than 10%.

With respect to water quality, once the treatment plant was implemented, Cinara carried out a monitoring from September to December 1997, taking as sampling points the raw water inlet and outlet from each treatment barrier. “DelAgua” equipment was used to measure pH, turbidity, and faecal coliforms. As shown in Table 5, the average of the parameters revealed that the quality of water produced by the treatment system complies with the national sanitary legislation.

Table 5. Sampling of water quality in the Mondomo treatment plant

<table>
<thead>
<tr>
<th>Sampling site/parameter</th>
<th>N</th>
<th>pH (units) Range</th>
<th>Turbidity (NTU) Range</th>
<th>Faecal coliforms (CFU/100 ml) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw water inlet</td>
<td>10</td>
<td>7.4</td>
<td>200–5.0</td>
<td>45–310</td>
</tr>
<tr>
<td>Outlet of coarse filters</td>
<td>10</td>
<td>7.8 – 8.2</td>
<td>&lt; 10</td>
<td>13 – 98</td>
</tr>
<tr>
<td>Outlet of the slow sand Filters</td>
<td>10</td>
<td>7.0–7.2</td>
<td>&lt; 5</td>
<td>0–2</td>
</tr>
</tbody>
</table>

N: number of cases
Source: Aponte (1998)

The results of a specific water quality sampling taken on April 23, 1998 are presented in Table 6. It is observed that water was re-contaminated in the network because the distribution network was 35 years old, so the following activity was to replace this network and then implement the disinfection system. Works are currently being concluded, with community resources and the support of the European Economic Community and national institutions. It is important to point out the level of
commitment of the private construction company which, as a product of the learning process, has become involved in the project as a contributor to ensure the satisfactory completion of the works.

### Table 6. Results of water quality sampling in the supply system

<table>
<thead>
<tr>
<th>Sampling site/parameter</th>
<th>pH (units)</th>
<th>True color (CU)</th>
<th>Turbidity (NTU)</th>
<th>Faecal coliforms (CFU/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw water inlet</td>
<td>6.8</td>
<td>&lt; 10</td>
<td>&lt; 5</td>
<td>100</td>
</tr>
<tr>
<td>Dynamic filter outlet</td>
<td>6.8</td>
<td>&lt; 10</td>
<td>&lt; 5</td>
<td>132</td>
</tr>
<tr>
<td>Coarse filter outlet</td>
<td>6.8</td>
<td>&lt; 10</td>
<td>&lt; 5</td>
<td>56</td>
</tr>
<tr>
<td>Slow sand filter outlet</td>
<td>7.0</td>
<td>&lt; 10</td>
<td>&lt; 5</td>
<td>1</td>
</tr>
<tr>
<td>Household at critical point in the distribution network</td>
<td>&lt; 10</td>
<td>5</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Source: Aponte (1998)

In addition, Cinara with the support of UNICEF-Colombia has begun a pilot program for water quality surveillance and control with community participation. Within the framework of the Colombian legislation, it aims at promoting the active and creative participation of the communities through the so-called Control Members, who are the legal representatives of the Committees for Development and Social Control established under the guidance of the Superintendence of Public Household Services in the country.

### 4.3 The case of Mundo Nuevo

Mundo Nuevo is 8.5 km from the municipality of Pereira, capital of the department of Risaralda. It is located in the eastern part of the municipality at 1,550 meters above sea level and has a mean temperature of 19 °C. The population is 1,600 inhabitants. The main economic activity is technified coffee farming. It has an elementary school and a high school. The water supply system works by gravity, fed by a surface source; heavy rainfall causes deterioration in water quality.

As part of the program for the transfer of water supply technology and methodology, carried out between September 1995 and July 1998, the locality of Mundo Nuevo was selected to develop a joint learning project. The linkage process was part of the activities carried out by an interinstitutional and interdisciplinary regional working group formed by staff members of the Sectional Health Service, the Departmental Committee of Coffee Producers, the CARDER, the Regional Autonomous Corporation, public companies, and the Technological University of the municipality of Pereira. The program was endorsed and supported by the Assembly and the departmental government. Cinara was the facilitator and the entity responsible for guaranteeing the implementation of the activities.

The community of Mundo Nuevo participated in the project planning and selected the multiple stage filtration technology, MSF. It was also involved in the design of the
In February 1998, the plant began to operate with two dynamic filtration units, two upflow coarse filtration units in layers and four slow sand filtration units (Table 7). The water supply system had the following components: intake; sand trap; main line; treatment plant; disinfection system; storage tank and distribution network. The design flow was of 5.0 liters per second.

Table 7. General characteristics of the treatment plant of Mundo Nuevo

<table>
<thead>
<tr>
<th>Parameter/Treatment barrier</th>
<th>Dynamic filtration</th>
<th>Coarse filtration</th>
<th>Slow sand filtration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of flow</td>
<td>Downflow</td>
<td>Upflow</td>
<td>Downflow</td>
</tr>
<tr>
<td>Treatment units</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Filtration velocity (m/h)</td>
<td>1.0</td>
<td>0.60</td>
<td>0.15</td>
</tr>
<tr>
<td>Filter medium</td>
<td>Size: 25-6 mm</td>
<td>Size: 25-3 mm</td>
<td>Effective size: 0.20 mm</td>
</tr>
<tr>
<td></td>
<td>Bed length: 0.80 cm</td>
<td>Bed length: 1.20 m</td>
<td>Bed height: 0.80 m</td>
</tr>
</tbody>
</table>

Source: Sánchez et al. (1996)

During the construction and start-up of the plant, but even more so when motivated by the evident change in the quality of the treated water supplied for consumption, the community participated actively in the consolidation of the Water Administrative Board, elected a new Governing Board, studied and approved in a general assembly both rules and regulation of users, and increased water rates to fully cover the operation, maintenance, and management of the system. The administrative entity has legal recognition and is registered in the Chamber of Commerce of Pereira.

With community participation and institutional support of Empresa Aguas y Aguas of Pereira (formerly Empresas Públicas de Pereira), the Health Service, the Committee of Coffee Producers, and Cinara, the supply service currently has 100% coverage; water is provided 24 hours a day, and the quantity satisfies all community needs, with a monthly consumption of 20 m$^3$ per user. With reference to water quality, Graph 5 shows prefilter patterns with a peak of turbidity on February 10, 1998, and Graphs 6 and 7 give the results of specific samplings carried out by the Health Service and Cinara (Sánchez, personal communication 1998), where efficiency of faecal coliform removal with MSF was observed.
Figure 5. Pretreatment pattern with a turbidity peak in raw water

Figure 6. Faecal coliforms in the influent and effluent of the MSF plant
Figure 7. Treatment efficiency (Faecal coliforms): MSF plant

7. Conclusions

The technology of multiple stage filtration, MSF, has produced water with low levels of turbidity and true color in compliance with national sanitary standards. In the case of faecal coliforms, the microbiological risk is low and meets WHO recommendation (1996) of maintaining average values of <3 and maximum values of <25 CFU/100 ml to achieve effective disinfection.

However, recontamination has occurred in structures and conduits due to the absence of chlorine contact chambers in the plants, necessary to achieve total inactivation of faecal coliforms before the last stage of MSF. It should be emphasized that usually the storage tank is the unit used for the disinfection process; however, contact time is variable in this tank, and depends on water demand. This aspect was underlined by Geldreich et al. (1990) when the chlorination efficiency seemed to diminish, but this drop in efficiency was basically due to the short retention time caused by an increase of water demand.

Considering the quality of the water supply service in general, the experiences of the projects have been most enriching, with important achievements and lessons for the sector. One essential concept relates to the understanding that sustainability is not a final state. On the contrary, it is a build-up process that should be permanently supported to identify opportunely the problems and limitations that affect the operation and use of the systems, and correct them with the active participation of the community and local institutions. In this respect, the following aspects can be pointed out:
• The selection of a technological alternative should be based on recovery and integration of knowledge and experiences both of the community and institutions involved in the project.

• The demystification of the technology, and the involvement of the community and its leaders in the whole process, with ample information and technical and social knowledge, generates a proactive attitude toward the systems and helps the community to develop a sense of ownership and commitment.

• Inspection by the community, if well oriented, is a mechanism of control and supervision that contributes to the quality and transparency of processes.

• The participatory processes should promote leadership with values such as transparency, justice, equity, respect, and responsibility.

• A basic condition for the strengthening or consolidation of a water and sanitation company is that the technical components of the system should work properly.

• Communities require permanent institutional support at all the phases of the project to facilitate the management and operation of the systems.

• The promotion of payment of water rates should include education to enable the community to understand why they should pay for the water, why consumption should be measured and controlled, and what the implications are of a good-quality water in sufficient quantity to cope with the community’s needs.

• Planning, operation and maintenance, commercial management, and relationship with users are essential aspects for the sustainability of the systems.

• Respectful and tolerant horizontal contact enables the communities to accept institutions as an important support for the solution of their problems, and it enables the institutions to accept communities as people capable of generating their own development.

• Coordination among institutions facilitates comprehensive solutions, since the problems of the community can be addressed by institutions involved in different types of social mission.

8. References


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