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Community partnered projects: a case study of a collaborative effort to improve sanitation in a marginalized community in northwest Mexico

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Abstract There is a growing recognition in developing countries that community participation in water and sanitation projects is a necessary strategy in sustainable development. The main advantage of following such an approach is that, if participation can encourage a sense of ownership of the projects, the benefits of the project are more likely to extend over the long term. The case study at hand focuses on the challenges faced in implementing a wastewater treatment system to solve an environmental and public health problem in a rural community, Rosario de Tesopaco, in northwest Mexico. Until recently, the community has been unable to implement an effective plan to treat the wastewater generated in the community. The problems faced by the community can be attributed to the political arrangement of water and sanitation decentralization in Mexico that occurred in the mid 1980's, whereby communities were required to meet wastewater treatment standards, but were not given the technical and political guidance needed to achieve this goal. However, in this instance, cooperation between the authorities in Rosario de Tesopaco, the federal agency for social development, and an academic institution has led to the successful design and approval of a wastewater treatment project. This achievement can be attributed to the use of an effective collaborative strategy, tailoring the project to the needs and capacity of the local community, positioning the community as the leaders and owners

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of the project. A model for following this strategy for developing rural sanitation projects in Mexico is proposed.

Keywords Rural development · Poverty · Environmental health · Public participation · Local governance · Northwest Mexico · Sanitation · Wastewater treatment

Abbreviations

BOD	Biochemical oxygen demand
cm	Centimeters
CNA	National Water Commission (Mexico)
CONAPO	National Population Council (Mexico)
DGAPA	Direction of Drinking Water and Sewage under the extinct Department of Hydraulic Resources (Mexico)
EPA USA	Environmental Protection Agency (USA)
GIS	Geographic information system
INEGI	Federal Agency for Statistic and Geographic Information (Mexico)
ITSON	Technological Institute of Sonora (Mexico)
km	Kilometers
l	Liters
m	Meters
m^2	Square meters
m^3	Cubic meters
mg/ l	Milligrams per liter
MPN	Most probable number
MTU	Michigan Technological University (USA)
SEDESOL	Federal Agency for Social Development (Mexico)
TSS	Total suspended solids
UNISON	University of Sonora (Mexico)

1 Introduction

Rural communities in the developing world face many problems that can negatively influence the outcome of development projects. The problems can begin during the project identification, design and construction stages, and can continue during the operation and maintenance. It has been found that, when development projects are more complex, community support is critical, mainly with respect to technical specifications and cost estimates, environmental protection considerations, and obtaining bureaucratic approval for projects (Cairncross 1992; De Silva 2000; Howe and Dixon 1993; Lyer et al. 2006; Narayan 1993; Reed 1995). Case studies describing the reasons for failed water and sanitation infrastructure projects can be found throughout the developing world (Alvarez-Vigil 1982; Carter et al. 1999; Foster 2000; Mackintosh and Colvin 2003; Pena and Cordova 2001; Ratner 2004).

Among the main factors causing failure of water supply and sanitation systems in rural communities is that the needs assessment, conceptual and detailed design, and construction of the systems are often conducted without participation from the rural communities that would benefit from these systems. This practice can result in the situation where the communities have to solve problems that they may not understand and thus are incapable of solving on their own (Alvarez-Vigil 1982). Lack of involvement of the people to be benefited by these projects creates the expectation that the government will provide the necessary services and funding. This expectation is related to the fact that in many rural communities of the developing world the users do not pay for their water and sanitation services (Carter et al. 1999; Pena and Cordova 2001). Communities may have never taken ownership and have consistently depended on funding agencies which often will lack resources to keep projects functioning after construction is completed (Foster 2000; Messenger 2004). Communities may also not believe in the benefits promised by the project designers. They may have priorities other than having new water sources or facilities for disposing or treating their domestic wastes (Carter et al. 1999).

Political structures can also contribute to the lack of success of rural water and sanitation projects by not providing financial and technical assistance or by creating bureaucratic barriers related to the process of obtaining funding and approval from government programs (Ratner 2004; Pena and Cordova 2001; Pineda 2006; Tortajada 2003). Lack of coordination among service providers and participating institutions can result in the waste of efforts and resources. Failures can also be linked to political issues within the community, in particular when the benefits that were promised to the general population by the government during the initial stages of the project do not materialize.

The success and failure of water supply and sanitation projects also is impacted by the fact that behavior and attitudes towards environmental health problems are complex and change slowly (Mackintosh and Colvin 2003; Reents 2003). Lack of socio-cultural information can detract from the appropriate diffusion of information related to outreach and education activities for water supply and sanitation programs. An understanding of the appropriate channels of communication in the community, an analysis of the coverage that these traditional channels provide and the credibility of the sources of information, interpersonal networks, and characteristics of the leaders in the community are critical (Alvarez-Vigil 1982; Pena and Cordova 2001).

When pursuing water and sanitation development projects in rural communities, the extreme poverty often encountered in these communities is an additional complicating factor. The poor are often excluded from the decision making process for water and sanitation projects because they are seen as being short term maximizers, and thus incapable of protecting the environment (Ravnborg 2003; Swinton et al. 2003). Low levels of participation in environmental protection projects can occur because community inhabitants are concerned with immediate concerns such as obtaining adequate food and shelter for their families. However, when poor individuals perceive environmental degradation as a threat to their livelihood, they are more willing to engage in environmental protection activities. They are more likely to engage in these activities when there is a sense of permanence and ownership of the projects in their community. Finally, citizen groups organized as environmental activists can contribute to higher levels of participation (Broad 1994; Ravnborg 2003).

Rogge and Darkwa (1996) advocate that strategies for reducing poverty and solving environmental problems should go hand in hand, and should involve the affected communities from the very beginning. In order to successfully implement projects that improve the health of communities in an impoverished region, increasing public participation and reducing economic inequities need to be considered (Nakajima 1994). The top-down approach for developing water supply and sanitation infrastructure has now been replaced by a new approach were new institutional arrangements have emerged, from privatization of drinking water and sewer services to decentralization. This new approach also seeks a

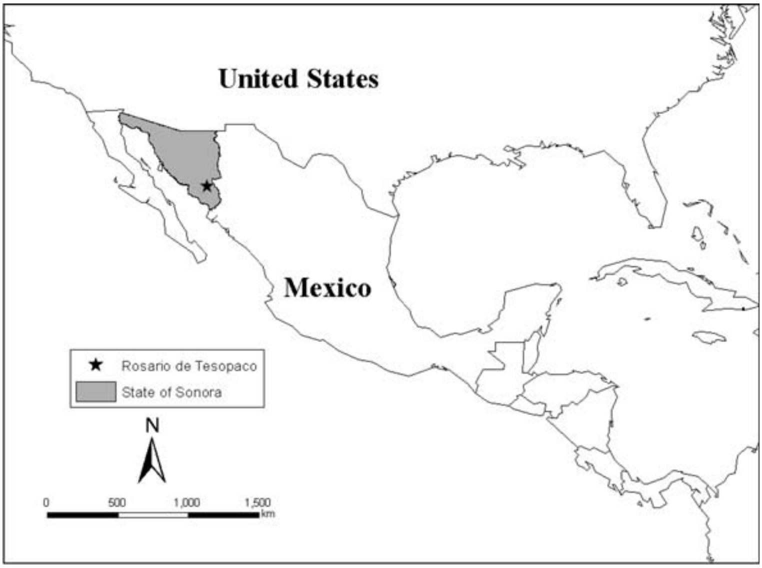

Fig. 1 Location of the state of Sonora and community of Rosario de Tesopaco. Source: GIS data depot 2004 (http://www.gisdatadepot.com): SEDESOL (2002); INEGI (2000)

larger involvement of the general population with the different levels of service (Pena and Cordova 2001). Organizations such as the World Commission on Environment and Development (Environment and Development 1987) and the World Bank (2003) have modified their approaches and are now required to use this model before they provide financial assistance (De Silva 2000; World Bank 2003).

This paper presents details of a sanitation project pursued in a community, Rosario de Tesopaco, which is located in a region considered among the poorest and most marginalized in northwest Mexico (see Fig. 1). The project consists of technology selection, detailed design, obtaining governmental approval and funding, and construction of a centralized wastewater treatment system. The unique aspect of the process was the collaboration between the local governmental officials, a federal governmental agency and an academic institution. It is suggested that this collaborative model allowed the sanitation project to move from conception to successful implementation in the hands of the local community. This case study describes the barriers that were surmounted in this particular project and the remaining measures needed to make the project successful in the future. Finally, we suggest that this type of collaborative model can be applied by other communities in their efforts to improve their quality of life.

2 Institutional factors affecting water and sanitation issues in Mexico

In Mexico, at the end of 1982, officials in the federal government realized that the centralized water resources agencies were unable to handle all the sanitation projects required in the country (Pineda 2002). A reform, signed into law in early 1983, promoted the decentralization from federal to the state and municipal levels in order to distribute the responsibility to states and municipalities (Pena and Cordova 2001; Pineda 2002; Machado

2003; Tortajada 1998). This reform and accompanying agreements effectively transferred all water supply and sanitation related administration, infrastructure, investment and legal responsibility to the hands of states and municipalities (Garduño 1998; Machado 2003; Tortajada 1998; Pena and Cordova 2001). The states were allowed to decide which municipalities would be given control over the water and wastewater management.

Improvements in sanitation coverage, however, have progressed slowly (Pineda 2006; Tortajada 2003). In 2003, Mexico generated an estimated 255 m^3/s of municipal wastewater and 258 m^3/s of industrial wastewater. In the same year, there were 3,000 wastewater treatment plants for both municipal and industrial dischargers with a total operating capacity of 88 m^3/s, resulting in a rate of only 17% wastewater treatment coverage (Tortajada 2003; CNA 2003). Furthermore, the quality of the effluent of existing wastewater treatment plants has been questioned (Tortajada 2003). An estimated 1.1 billion kg/year of biological oxygen demand (BOD_5), which is a measure of organic strength of wastewater, was generated in 2003 from municipal and industrial sources. However, only 135 million kg/year, or 13%, of the BOD_5 was removed in engineered wastewater treatment systems (Tortajada 2003; CNA 2003).

Pineda (2002) has surveyed locations where management responsibilities were transferred to municipal authorities. He found that, in general, services have tended to deteriorate and to be more inefficient. In most cases, municipalities were yet to become autonomous organizations that could fund and implement their own projects. Pineda (2002) identified two critical factors in the future of water supply and sanitation management in Mexico: the enforcement of regulations and mechanisms that would allow managing organizations to be self sufficient, both economically and intellectually. In particular, rural communities are faced with the challenge of developing networks to give them the capacity to pursue development projects, in terms of funding opportunities, technological expertise, and obtaining bureaucratic approval.

In general, the procedure for sanitation and water supply projects for rural communities in Mexico follows these steps: (a) a federal agency identifies the need for a project or rural communities request assistance from federal agencies; (b) if the agency does not have technically qualified staff, the agency hires a private consulting company to develop a solution; and (c) a private company is hired to construct the project. The disadvantage of this approach is that communities are left out, for the most part, during the design and construction phases. Lack of community involvement creates the expectation that the external government agencies will provide indefinitely the necessary services and funding to maintain systems. The communities may not believe in the benefits promised by the project designers and thus may not see that it is in their self-interest to maintain the project. The goals and objectives established by the designers may differ from those of the community and important issues such as educational programs regarding personal and household hygiene, and environmental protection are neglected.

3 Background on Rosario de Tesopaco

The rural town of Rosario de Tesopaco is located in the southeast part of the state of Sonora in Mexico. The town is positioned at the foot of the Sierra Madre Occidental mountain range, about 300 km away from the state capitol, Hermosillo, and about 90 km away from the nearest urban center (Ciudad Obregon). The population in the town of Rosario de Tesopaco was estimated at 2,650 people in the latest census (INEGI 2000). As with most rural towns in Sonora, the population is decreasing due to emigration to the cities in search of better economic opportunities. Data obtained from the Mexican census (INEGI 2000; CONAPO 2000) shows that the town of Rosario has experienced a negative (−3.6%) population change from 1990 to 2000.

The major economic activity in the region is raising livestock, particularly cattle. Agricultural activities in the region are mostly for self-consumption and to sustain the ranching activities. Mineral extraction (graphite and iron) industries provided employment in the 1900's but are no longer active. Industry in the region is minimal, due mainly to the distance from the main consumer and transportation centers and the lack of services needed to establish industries. Two chicken farms were opened in the late 1990's and provide a source of employment for about 100 families. There are also several small tanneries that produce partially processed leather. Most commerce is conducted at the small scale, with businesses consisting of 5–10 employees. There are several businesses that supply residents with basic products (groceries, hardware, and consumer goods) transported from the nearest urban centers.

The municipality of Rosario ranks among the top four highest marginalized areas in the state of Sonora (SEDESOL 2002). Poverty levels developed by the Mexican federal social services agency (Secretaria de Desarrollo Social, or SEDESOL) are classified according to three levels: alimentary, capacity, and patrimony poverty. Alimentary poverty refers to insufficient income to cover basic dietary needs; capacity poverty refers to insufficient income to cover dietary, education and health needs; and patrimony poverty refers insufficient income to cover dietary, education, health, clothing, house ownership, and transportation needs. For Rosario, the fractions of the total population falling under each of the three levels of poverty are: alimentary poverty 50%, capacity poverty 26%, and patrimony poverty 18% (INEGI 2000; SEDESOL 2002; CONAPO 2000).

The governmental structure of Rosario consists of a council of representatives from different economic sectors in the region. The council is led by the president of the municipality or county seat (Presidente). The Presidente's staff is composed of the secretary, the treasurer, director of public works, director of public services, and director of public security. Municipal Presidentes are elected through a democratic popular vote every 3 years. The elected Presidente appoints their supporting staff. In the municipality of Rosario, the department of public works consists of the director, secretary and an assistant. They are in charge of the construction projects in the entire municipality. In the current administration, the director of the department of public works has a civil engineering bachelor's degree from the Technological Institute of Sonora and is a native of Rosario de Tesopaco.

Drinking water systems in the municipality in Rosario de Tesopaco were first built in the late 1950's by the Federal Agency for the Direction of Drinking Water and Sewage (Direccion General de Agua Potable y Alcantarillado, or DGAPA) under the Federal Department of Hydraulic Resources. Water is available from pumped wells in the northern and southern part of town. Chlorine is added at the well heads for disinfection. Water quality is monitored through measurements of chlorine levels in the distribution system. Information provided by the local authorities indicates that several wells located in the southern part of town were shut down due to possible contamination of the groundwater (Robles 2005).

The sewage collection system in the town of Rosario de Tesopaco covers approximately 60% of the population. The original sewage collection system was designed and constructed in the early 1980's by engineers from the state government and funded by the federal government. The equipment and the majority of the labor employed also were provided by state and federal government agencies. At the same time the sewage collection system was constructed, DGAPA engineers designed and constructed an oxidation lagoon for treating the domestic wastewater. The lagoon was constructed adjacent to the creek that skirts the community and then flows south towards the town of Cedros.

However, the oxidation lagoon eventually failed due to poor communication between the design engineers and the community. When the lagoon was constructed, the design engineers had established an earth embankment to protect the lagoon from the seasonal flooding of the creek. To consistently provide protection from flooding, the embankment needed to be regularly maintained, but this requirement was poorly, if at all, communicated to the officials or residents of the town. The embankment slowly deteriorated until the lagoon was completely breached and emptied into the creek in the late 1980's. In addition, there were apparent failures in the design of the conducting pipeline, due either to improper selection of the materials or incorrect calculations of the pressures in the pipeline. A few years after the installation of the pipeline, it began leaking and later completely failed at the point halfway between the town and the intended point of discharge. This failure resulted in the creation of pools of untreated wastewater near the center of the community.

Data obtained from public and private clinics in the community showed that the most common diseases treated in the past years (1998–2004) have been acute diarrheic diseases. Infectious diseases such as gastroenteritis, *E. coli*, rotavirus, conjunctivitis, infectious hepatitis, giardiasis, salmonellosis, diarrheas, dysenteries, and intestinal parasites were recorded in the logbooks of the temporary medical staff (Robles 2005). Additional data showed that the infant mortality rates in Rosario are estimated at 29.9 deaths per 1000 births, which is among the highest five mortality rates in the state of Sonora (INEGI 2000). This information pointed to the problem of exposure to untreated sewage as a potential cause of these illnesses and infant mortality, but personal hygiene, food contamination, malnutrition, and other factors could also be causing these problems.

The town of Rosario had already experienced the construction and failure of the first sewage treatment system prior to the decentralization process that began in 1983. More than 20 years later, SEDESOL began a program to aid the marginalized, rural communities. In 2002, SEDESOL officials hired a consulting agency to design a new sewage treatment system for the town of Rosario de Tesopaco. This system was then to be constructed by private companies and then operated and maintained by the local authorities. This scheme was much like the centralized process experienced in the entire country prior to 1983. The objectives established for the consulting firm were to design a treatment system capable of producing treated wastewater that would be of sufficient quality to be used for irrigation of grasslands. The design submitted by the consulting agency was based on activated sludge technology. This type of technology is frequently used in urban areas in the industrialized world. However, the technology requires sophisticated operation and maintenance capabilities and has relatively high operation and maintenance costs, due primarily to the energy intensive nature of the system. The design was rejected because the operation and maintenance costs and required technical skills were excessive for the rural community.

4 Design of the new wastewater treatment system

After rejection of the activated sludge plant design, SEDESOL officials continued requesting local authorities to solve the problems associated with the untreated wastewater. At the same time, the Universidad de Sonora (UNISON), the primary university in the state, and Michigan Technological University (MTU) were developing educational and research collaborations in the area of environmental sciences and engineering. The federal agency SEDESOL requested help from faculty visiting from MTU in 2003 to design a wastewater treatment system suitable for this community. The request to MTU was to design a wastewater treatment system capable of meeting the Mexican standard for discharge to water bodies (NOM-001-ECO-1996) with minimal operation and maintenance costs and technical requirements. Furthermore, the possibility of reusing the treated wastewater for irrigation of grass was to be evaluated. The reuse of wastewater would require the treated wastewater to meet the Mexican standard for reuse (NOM-003-ECO-1997). SEDESOL officials also considered that this collaborative effort could serve as a pilot study that could be applied in other rural communities.

In response to this request, during the spring of 2004, two alternative wastewater treatment systems were designed by MTU faculty and students. The alternatives proposed by the group were a constructed non-vegetated subsurface flow wetland and a stabilization pond. Both systems were capable of treating the wastewater with minimal maintenance or operation costs and were designed to meet the Mexican standard for discharge to water bodies (NOM-001-ECO-1996). The design report was submitted to be evaluated by the authorities in Rosario de Tesopaco and by SEDESOL officials. Although the constructed wetland was more expensive, it was selected by the authorities of Rosario de Tesopaco and SEDESOL because of the potential to meet regulations for the re-use of wastewater for irrigating pasture.

A constructed wetland is defined as a wetland specifically constructed for the purpose of treating of domestic wastewater. There are two basic types of constructed wetlands: free water surface wetlands and subsurface flow wetland. Both types can utilize emergent aquatic vegetation and are similar in appearance to a marsh (Campbell and Odgen 1999). The subsurface flow wetland consists of an excavated basin lined with a barrier to prevent seepage and filled with a bed of gravel- or larger-sized materials. These systems are designed such that the water level in the bed remains below the top of porous media, hence the term ‘‘subsurface flow.’’ Flow through the operational system is horizontal (Arceivala 1981; EPA 1993).

In constructed wetland systems, dissolved and particulate organic material is decomposed by microorganisms that are living on the exposed surfaces of the aquatic plants and soils. The decomposers, such as bacteria, fungi, and actinomycetes, break down the dissolved and particulate organic material to carbon dioxide and water. These processes more or less mimic the degradation of organic materials in naturally-occurring wetlands. Potentially disease-causing microorganisms are removed by adsorption onto the porous media surfaces, are inactivated due to hostile chemical conditions, or are predated by other microorganisms (Kadlec and Knight 1996).

Parameters used for the design of the subsurface flow constructed wetland were obtained from SEDESOL personnel and a previous study of the design of a wastewater treatment system for Rosario de Tesopaco (Agua y Aire SA de CV 2003). The average wastewater flow was estimated at 5 l/s. It was assumed that wastewater consisted of household waste only (i.e. no industrial waste). The constructed wetland design relied on parameters and methods detailed in *Constructed Wetlands in the Sustainable Landscape* (Campbell and Odgen 1999) and *Subsurface Flow Constructed Wetlands for Wastewater Treatment Technology Assessment* (EPA 1993). The design calculations were made considering that the limiting factor was the wastewater retention time required to remove pathogens (using fecal coliforms as an indicator). Given this limiting factor, the influent wastewater characteristics, and the desired effluent characteristics, a wastewater retention

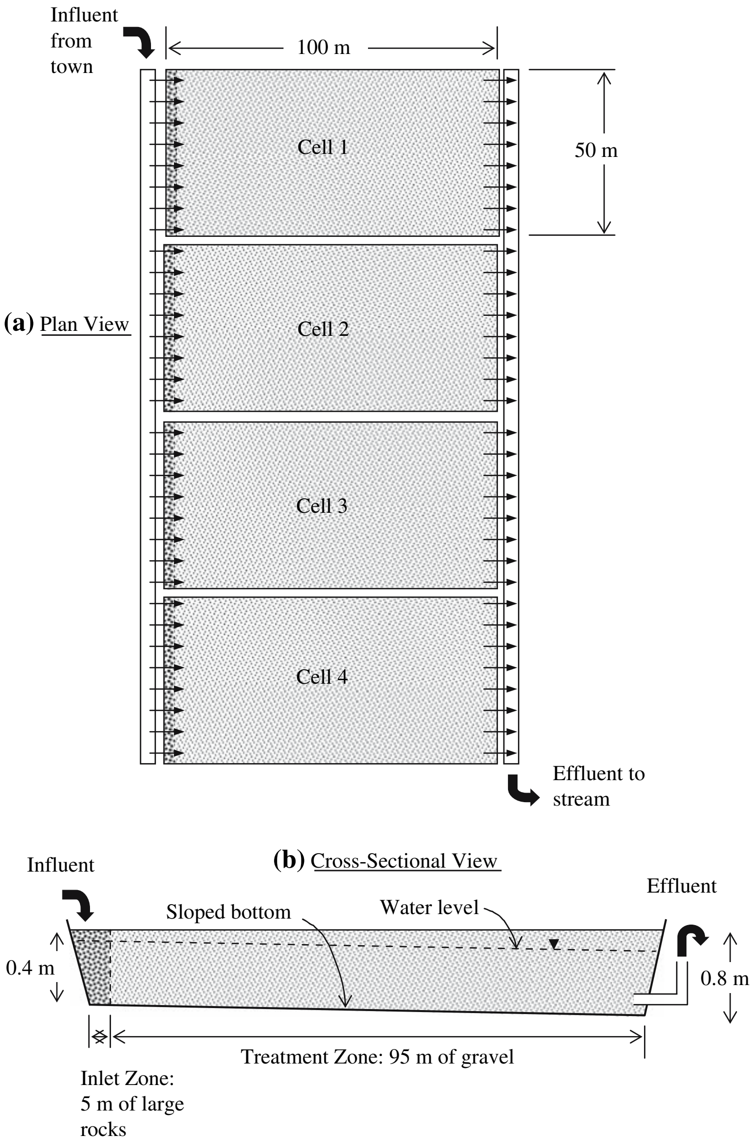

Fig. 2 Top view of the entire constructed wetland and cross section of a single cell

time of 4.4 days was calculated. The retention time, along with the wastewater flow rate, was used to determine the area and depth of the constructed wetland.

Figure 2 shows the top and cross-sectional view of the constructed wetland. The division of the influent wastewater into four separate cells allows for easier maintenance and more uniform distribution of the wastewater. Each cell has a length of 100 m and width of 50 m, resulting in a total area of 20,000 m^2. The depth of the media is 0.4 m in the inlet area, and 0.8 m in the outlet, giving a total bed volume of 13,000 m^3. The bottom of the bed is sloped at 4% to provide a driving force for the wastewater flow. Coarse media

Table 1 Wastewater characterization for Rosario de Tesopaco and Mexican wastewater regulations

Parameter	Influent value	Maximum allowable limits for effluent		Expected effluent value[c]	Units
		Discharge to water bodies[a]	Reuse of wastewater[b]		
pH	6.5–9.5	5–10	5–10	7	pH units
Biochemical Oxygen Demand	250–300	150	30	5	mg/l
Total Suspended Solids	225–250	150	30	24	mg/l
Fecal coliforms	1×10^8	1000–2000	<1000	590	MPN/ 100 ml[d]
Helminth eggs	N/A	<5	<5	N/A	Viable eggs/l
Grease and oils	<50	15	15	N/A	mg/l
Floating material	present	absent	absent	N/A	Visual
Total dissolved solids	5–10	1	1	N/A	mg/l
Total nitrogen	53.4	40	40	0.6	mg/l
Total phosphorus	16.11	20	20	N/A	mg/l
Temperature	23.6	40	40	N/A	Celsius

Source: CNA (2006); SEDESOL (2004); Agua y Aire SA CV (2003)

[a] Type A, NOM-001-ECOL-1996

[b] with indirect or occasional contact, NOM-003-ECOL-1997

[d] Calculated with design equations; N/A: Not applicable

[c] MPN: Most probable number

(average size of 0.7 cm) is placed in the inlet of the system and finer media (average size of 0.5 cm) is placed in the treatment zone. The piping systems are designed to provide uniform flow across the inlet and outlet. The inlet is designed to allow screening of larger materials that could clog the treatment bed and also to permit easy access to remove these materials.

An embankment surrounds the wetland to protect against flooding from the nearby stream. The distance from the edge of town to the location of the proposed construction site is 1.2 km. The effluent of the wastewater is to be directed to the nearby (50 m away) stream. Table 1 shows the influent and expected effluent characteristics as well as the desired effluent characteristics established by the Mexican regulations for discharging into water bodies or for reuse.

5 Gaining approval for the project

While the design of the subsurface flow constructed wetland followed well-established technical guidelines, there was no opportunity for the design group to interact with the community during the design process in spring 2004, due to the obvious problem of distance between MTU and Rosario de Tesopaco (approximately 4,300 km). The lack of community interaction meant that opportunities for potentially critical chances for input from town residents were missed, including input on such important issues as (a) establishing the necessity of a wastewater treatment facility in the first place, (b) appropriateness of the choice of treatment technology, (c) acceptance of the diversion of limited financial and human resources towards the project, and (d) acceptance of responsibility for the operation and maintenance of the facility.

However, the first author, who was part of the MTU design group, lived in Rosario de Tesopaco during summer 2004, while conducting an ethnographic study (Robles 2005). The purpose of the ethnographic study was to examine the different roles of the institutions involved and understanding the beliefs and values of the general community of Rosario regarding the problem of wastewater. The presence of the first author in the community and the data collected in his study allowed for his participation in the process of gaining approval for the project.

After the acceptance of the MTU design by community officials and SEDESOL, the next step was for the community officials to submit a written design proposal to be evaluated by the Hydraulics Works Department of the Mexican National Water Commission (Comisión Nacional del Agua, CNA) for technical approval. The technical approval from the CNA was required before applying to SEDESOL to obtain the funding to construct the project. However, since the MTU design document had been prepared in the absence of contact with the community, there was no one within the community who was cognizant of the principles underlying the design. Furthermore, the fieldwork conducted by the first author revealed that local government officials of Rosario de Tesopaco were primarily interested in the wastewater facility for bureaucratic reasons. The federal agencies (CNA and SEDESOL), had told the officials that they would not receive funds for any other projects (e.g. irrigation canals and housing improvements) until they had submitted a proposal for dealing with the untreated wastewater.

The local government officials were reluctant to embrace the wastewater project as a priority (other than the fact that it was holding up funding for other projects) because they (a) did not see the project as improving quality of life in the community, (b) lacked the technical background to understand the fundamental principles underlying wastewater treatment and disposal issues, and (c) felt that, since the project was being imposed on the community by the federal agencies, the community would not have control over the design, construction and operation of the facility and that ultimately the community would see the project as a liability.

These problems were overcome by taking several actions. First, the information that was collected by the first author on the impact on public health from the local health clinics and through interviews of residents in the community was communicated to the local officials. This information demonstrated that there was a significant probability that the untreated wastewater was causing health problems and that some segments of the community understood the linkage between the untreated wastewater and health problems in the community.

Second, the first author was able to demonstrate how communications with community members about projects, from the planning to implementation, could contribute to the ultimate success of those projects. The importance of communication was demonstrated with an example of an ongoing project in which the local government was expanding a section of sewage network to connect more residences in the community. The sewage network connections were to be provided only where residents could pay for the required materials. Since the residents were not informed of the need to pay until after the construction of the sewer line began, they were unable to do so because they had not put aside the required funds. Thus, a significant fraction of the residents in this area were left without connections to the sewer network. This problem could have been prevented with better planning and information disclosure.

Third, because the community officials had not been involved during the design process, it was necessary to educate the officials as to the reasoning behind each aspect of the design. The task began with the translation of documents and blueprints, as well as making a topographic survey to select a new location for the lagoon. In series of meetings, the first author explained and justified the critical details of the, such as the leveling of the ground, the creation of an earth embankment that prevented floods from destroying the lagoon, details of the collection and distribution system, and the maintenance required for the system.

Fourth, as mentioned previously, the primary motivation for initiating the wastewater treatment project came from the federal social services agency (SEDESOL), which had determined that exposure to untreated wastewater was a threat to the community's health. SEDESOL officials continuously advocated that solving the wastewater problem would improve the quality of life in the community, especially for the poorest members of the community, who were most likely to be exposed to the untreated wastewater. Poorest members of the community tend to live on the edge of town, nearby the creek containing the untreated wastewater. Despite this fact, this sector of the town's population had the least understanding of the connection between exposure to the untreated wastewater; and their everyday work and recreational activities (Robles 2005).

In June 2004, the project was submitted to the CNA for approval. A few days later, the project was rejected by the CNA evaluator on the basis that (a) the local authorities had no technical expertise to design and build such treatment system and that other, projects such as the extension of sewage networks and irrigation cannels submitted previously by the local administrators had errors in the design; (b) insufficient evidence was provided to show that the treated wastewater could be reused for irrigation; and (c) a particular technical detail was missing: a topographic survey for the conduction lines required for the lagoon.

The local authorities, representatives from SEDESOL, and the first author set about to correct these problems. The first issue (the perceived lack of expertise on the part of the local government) was dealt with by resuming discussions on the design with the Presidente of the community and the local director of public works. The goal of the discussions was to prepare the Presidente and the director of public works to be able to defend their expertise in a hearing with the CNA. As for the second issue, the plan for re-using the wastewater was withdrawn. The new plan had the effluent being discharged directed to the local creek, with a provision for monitoring the quality of the effluent. If the effluent quality could be shown to meet specific requirements over a 12-month period, the local government could then re-apply for permission to re-use the treated wastewater for irrigation. The third issue was handled by promptly conducting the required topographic survey.

During this period, the local officials expressed the concern that the costs of the project were relatively high, since they perceived that a high-cost project would limit the availability of funding for other projects. When the costs were reviewed, it was found that the original estimates could be sufficiently reduced. The major cost reduction (about 25% relative to the original cost) was achieved by a plan developed by the local government officials, whereby the required construction labor would be provided by local workers, a local source would be used for the gravel fill in the constructed wetland, and a new, cheaper vendor for the geo-synthetic liner was found. These changes not only reduced the costs of the project, but they also provided more local control over and involvement in the project construction.

After improvements to the design proposal were made, in mid-July 2004, the local authorities of Rosario requested a hearing for the re-evaluation of the project. The hearing was rejected because the evaluator did not believe that the local government was capable of making the improvements required to make the project approvable. In a final effort, officials from SEDESOL obtained a special hearing with the CNA in which the Presidenté and local engineer successfully defended the design and the objectives and highlighted the improvements to the original proposal. The evaluator saw that the local engineer could explain with detail and in his own words the basic principles of the treatment process, the critical aspects of the construction, and the maintenance requirements. However, the evaluator also noted that he was assured by the continued involvement of the first author, as a representative of the university responsible for the original design.

The project proposal was pre-approved at that meeting, and was sent to Mexico City to be evaluated in more detail by the CNA headquarters in Mexico City. In late August 2004, the official evaluation was completed. The project was approved, with only minor comments suggesting more that more explanations be added to the blueprints with regard to the conduction line. Having been approved by the CNA, the community of Rosario was granted financial resources from SEDESOL in December 2004 of about $300,000 USD to build the constructed wetland. At this time, the local government of Rosario made the commitment of absorbing all the maintenance and operation costs required for the future of the system. This commitment was relatively easy since the maintenance and operation costs were low- an advantage of the constructed wetland technology.

The construction, which was directed by the local director of public works, began in February of 2005 and was completed in fall 2006. Local students from Rosario de Tesopaco pursuing degrees in Civil Engineering were also hired as supervisors and many people in the community have been participating actively in the construction process employed by the municipal government.

6 Lessons learned

The factors affecting the implementation of the subsurface constructed wetland project in Rosario de Tesopaco can be attributed to the political arrangement of water and sanitation decentralization in Mexico. The policy of decentralization implied that water and sanitation coverage in Mexico would be improved since local communities would be more involved in decision making. In reality, however, these communities may not have financial resources, and the technical, management and political expertise to complete these projects on their own. Furthermore, there do not appear to be any resources available to the communities to gain the needed expertise.

These issues resulted in the community of Rosario de Tesopaco having to contend with a paradox: the community was required to meet certain standards with regard to wastewater treatment, but were given no guidance as to what institutional steps were needed to achieve this goal. Even worse, when the community eventually submitted a proposal to correct the problem, the proposal was rejected out of hand, since the institution evaluating the proposal did not believe that the community was capable of solving the problem on their own.

However, in this instance, collaboration between the authorities in Rosario de Tesopaco, the sponsoring agency, SEDESOL, and an academic institution, MTU, eventually led to the successful design and approval of a wastewater treatment project. Although the involvement of MTU and SEDESOL were crucial from a technical and political standpoint, these institutions attempted to tailor the project to the needs and capacity of the local community and to position the local authorities as the leaders and owners of the project.

The design of this project transpired at an academic institution (MTU) with little physical connection with the community, leading to minimal participation of the general community in the early stages of the project. However, this potential limitation was overcome by following the design process with a social anthropology study conducted by a representative of the institution. The presence of this individual was useful in that he could demonstrate effective ways of obtaining public participation and provide evidence of the potential, positive impacts of the project in relation to human health. Furthermore, since he had participated in the design of the project, he was able to transfer critical technical knowledge to the local authorities.

This case study also demonstrated that a critical aspect for gaining acceptance of this particular sanitation project was to give the community an opportunity to gain ownership of the project. The initial sentiment of the community leaders was that, since the project was being imposed by federal agencies, the community would not have control over the construction and operation of the facility and the community would see the project as a liability. However, when they came to understand the technical aspects of the project, exerted control over the project costs, and committed to using local resources for construction, the gaining of approval and eventual construction of the project became a high priority.

The broad findings and implications of this study can serve as guidelines for other communities elsewhere, since many towns in rural Mexico and elsewhere share similar problems. The importance of the study lies in trying to understand the challenges faced by the institutions that came together to work and to be able to carry this project from the establishment of the need for the project, to the engagement of a university with expertise in the technical and social aspects of sanitation projects, to gaining bureaucratic approval, to full implementation and, eventually improvement of the standard of living in a remote community. In this case study an academic institution played a key role acting as an external advisor and a bridge for the collaboration that took place with government agencies.

We propose that the roles that the collaborators played and the steps that were followed towards implementation of the sanitation project in Rosario de Tesopaco can be incorporated into a general model. This model is illustrated in Fig. 3. In this figure, three primary collaborators have been identified. ‘‘Community’’ refers to the inhabitants and relevant officials—primarily the Presidenté and technical staff—of the community. ‘‘Federal/state agency’’ refers to the governmental agency(ies) that are supporting the project, by having identified the need for a sanitation project and by providing a portion or all of the funds needed to implement the project. It is likely that this agency will be SEDESOL, as was the case in Rosario de Tesopaco. ‘‘Technical institution’’ refers to an academic institution or NGO that can provide expertise in both the technical and social aspects of sanitation projects, and is willing to provide this expertise for little or no remuneration from the community or federal/state agency. It is important note that the technical institution(s) is expected to be involved beyond construction, to assure that the project is being operated, maintained and monitored properly.

The model described in Fig. 3 is based on the premise and finding in this case study that the community needs to be involved and given every opportunity to gain ownership of the project, from the needs assessment, to selection of alternatives, to construction, and to operation. Ownership is important not only to ensure that the project will be accepted by

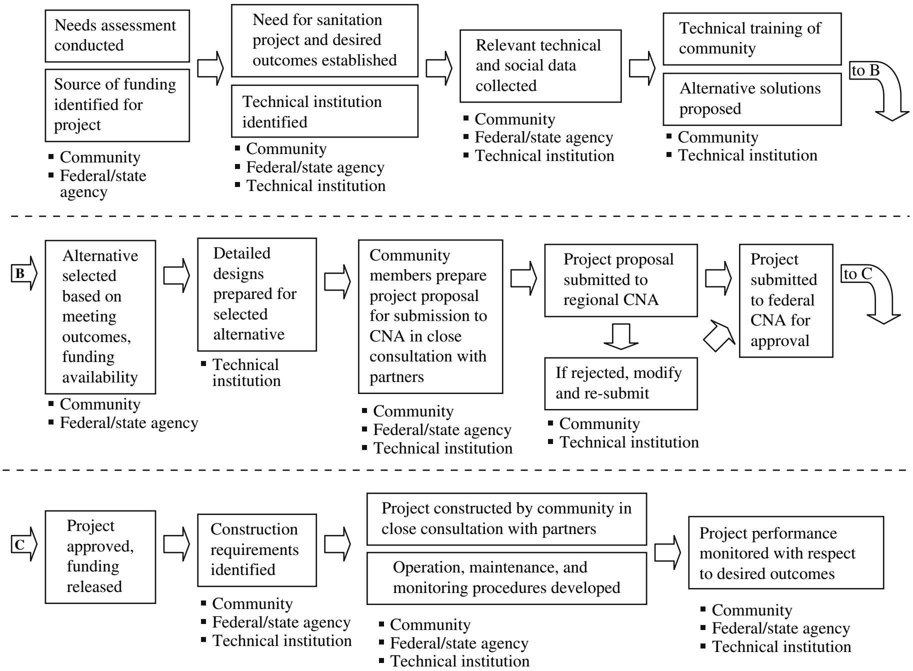

Fig. 3 Collaborative model for developing rural sanitation projects in mexico

the community and properly maintained and operated through its lifetime, but also to make certain that the authorities granting approval for the project are assured that the community has the capacity to handle the project from a technical and administrative standpoint.

7 Future work

There are several remaining steps that should be followed to ensure that this project is a complete success. First, diffusion of information to the community regarding the project and the role of sanitation in public health is critical. The community is already incorporating a civil group, as well as teachers and students from the local high school, to develop an outreach and educational program. This program must be conducted in collaboration with the local health clinics that can provide information about the benefits of this wastewater treatment system and the importance of having parallel programs that improve personal and household hygiene, nutrition, reduction of vectors, etc., that will improve the overall health of residents in this community.

Second, a technical training program on maintaining and operating the constructed wetlands is necessary. Although the system is designed to relatively simple to operate and maintain, the integrity of the system must be protected by preventing damage or leaks in the embankments surrounding the wetlands and removing debris from inlet and outlet structures. MTU is currently working with the local engineer to develop a manual that details these issues and provides a troubleshooting guide.

Third, as mentioned earlier, the intention of the local community is to re-use the treated wastewater in the irrigation of grasslands for raising cattle. This requires that a monitoring program be established to prove compliance to the Mexican norm for wastewater re-use (NOM-003-ECO-1997). Once the sufficient data on the removal of pathogens is collected, the community can apply for a change for the legal re-use of the treated wastewater. MTU is working with SEDESOL and UNISON to obtain funding and technical capabilities for the monitoring program.

Fourth, the most significant contribution from this project is that it can serve as a guide for other communities that face similar challenges and apply a similar collaborative approach model to find solutions that are in tune with the priorities of funding agencies as well as the local priorities. This allows that different types of organizations that can range from local groups, to national and international NGOs, Universities and Governments can work together.

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