Dry sanitation toilets and grey water filters in Ciudad Juárez, Chihuahua, México

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ABSTRACT

The Center for Environmental Resource Management (CERM) at the University of Texas at El Paso (UTEP) located across the border from Ciudad Juárez, Chihuahua, México has been working in the areas of sanitation and water management for more than 10 years. During the last five years CERM has partnered with Centro Mujeres Tonantzin (CMT), a non profit organization based in Ciudad Juárez in the implementation of dry sanitation technologies in low income communities that lack of piped water and sewer. At the beginning of this partnership only a few families were interested in these systems, but with time and a lot of effort we have been able to change their mindset and now the demand is so great that families register in a waiting list hoping to be participants of the next funded project. Unfortunately, we have not been able to allocate funds for all families but we see it as a success to have more families interested in this type of technology as an alternative to pit latrines. Now we are building ecological toilets with shower included that discharges into a grey water filter that serves as water reservoir for other home uses such as car washing and plant watering.

This paper is a chronology of projects developed by CERM in the area of dry or ecological sanitation. We present published results of the different toilets we have built and tested, advantages and disadvantages of each system and why they worked or not in our particular region. Results from an evaluation research study of the grey water filters show amounts of water delivered by these systems and perceptions from community residents. We present

some of the comments from the participating families on how they think we are improving their quality of life through their active participation. We mention the different partnerships that we have created with other organizations and possibilities for growth.

INTRODUCTION AND BACKGROUND

About fourteen pairs of twin-cities along the U.S.-México Border have experienced dramatic population growth in the last two to three decades. El Paso in the USA and Ciudad Juárez in México have the largest population of all these pairs. With this increase in population municipal governments have not been able to meet the demand for piped water and sewage services. Sewage treatment is particularly costly so the installation of effective treatment systems often lags behind need. These systems also require large amounts of water to operate properly. It has been determined that approximately 80 countries with 40% of the world's population experience water shortages at some time during the year [1].

The most common sanitation system in the world is the pit latrine, which in its basic form is a primitive shelter placed over a hole in the ground. Once the hole is full, it is covered with dirt and a new one dug. This system is also popular in the El Paso / Ciudad Juárez border region; however, due to rocky ground conditions and hilly topography, pits are often hand excavated too shallow and narrow. In addition the unconsolidated sediments on the upper most part leaks the poorly contained matter within them. Therefore, pit latrines are often cited as the cause of contamination to groundwater and nearby surface waters in many areas throughout the world. Researchers have shown that when bacteriophages were introduced as biotracers into pit latrines, it takes only days before the bio-tracers contaminate wells up to distances of 50-100 meters [2].

Despite efforts by the municipal water and sanitation utilities of Cd. Juárez (JMAS for Junta Municipal de Agua y Saneamiento), 12 % to 20 % of the city population remains without direct access to water and sewage lines [3]. This lack of infrastructure results in polluted environments that increase the rate of disease for approximately 400,000 Mexican nationals living within Juárez greater metropolitan area. In México as a whole, gastrointestinal diseases are leading causes of death among children [4]. In 1993, the Pan American Health Organization (PAHO) determined mortality from enteritis in the age group 0 to 5 years in México to be 52.7/100,000 [5]. For the specific case of Juárez the Mexican Federation for Private Health and Community Development Associations (FEMAP) found unusually high rates of parasitic diseases, skin infections, diarrhea diseases, and dehydration [4]. Many of these health problems are associated with a lack of adequate excreta waste disposal systems, which in turn, is the result of other factors including inadequate financial resources, insufficient water supply, and limited institutional capabilities [2].

A study of well water and tap water in Cd. Juárez found that of 12 samples of well water, 11 were positive for fecal coliforms and, of 30 samples of tap water (that had supposedly been chlorinated), 18 were positive for fecal coliforms [4]. Many of these health and environmental problems are associated with a lack of adequate excreta waste disposal systems. In El Paso County, there are an estimated 16,414 residents that lack piped water supplies and 48,180 residents that have inadequate wastewater systems (e.g. outhouse or cesspool). Along the U.S. side of the U.S.-México border, the rates of *Shigella* and *Hepatitis A* are four times the national average [6]. In a 1998 study, pregnant women in El Paso and Cd Juárez were tested for *Hepatitis A* virus (HAV) antibodies with resulting rates of 75.8% (n = 557) in El Paso and 96.0% in Cd Juárez [7]. HAV is transmitted by the fecal-oral route and transmission of hepatitis A is strongly associated with poor sanitary conditions and low socioeconomic status. Another study conducted in San Elizario, a town within El Paso County, found that in younger children (n = 561), ages 3-7 years, 16.9% tested positive for having been infected with hepatitis A [8].

Controversy still exists over which water and sanitation interventions are most effective for reducing diarrheal morbidity. In a study of eight different countries, improvements in excreta disposal demonstrated greater health benefits than did improvements in water supply [9]. The United States Agency for International Development (USAID) completed an extensive review to quantify the impact of each type of intervention by determining the median percentage reduction in diarrheal disease morbidity [10]. The study found that improvements in excreta disposal resulted in a 22 % median reduction in diarrheal disease morbidity [10].

In response to the communities plead for appropriate systems that would alleviate the many sanitation problems posed by their lack of sewerage, CERM decided to explore the area of ecological sanitation. There was little information on the topic in our region.

PROJECT DESCRIPTION

Wet composting toilets

With funds from the Paso del Norte Health Foundation, based in El Paso, Texas, CERM installed the first waterless toilets in 1999. The Integral System for the Recycling of Organic Waste (SIRDO, for Sistema Integral de Reciclamiento de Desechos Organicos, in Spanish) manufactured by Grupo de Tecnología Alternativa in México City, was chosen for the pilot project. The system is a one-piece single vault solar composting toilet made of plastic. Three hundred SIRDOS were installed in three peri-urban communities of Ciudad Juárez. The installation of these provided a low-cost technology that was a viable option for residents at that time.

During 2000 and 2001 a follow-up research project funded by the Southwest Consortio for Environmental Research and Policy (SCERP) was implemented to examine the quality of the end product of the operating composting latrines. Project staff developed a cohort design to follow a random sample of 90 SIRDOs. The quality of biosolids from the SIRDOs was measured at three and six months after installation. Sample results were analyzed across all three communities and compared to identify any differences in outcome between the areas.

Based on laboratory analyses of latrine sludge, classifications of the composted material were made based on the United States Environmental Protection Agency (USEPA) standards. Class A compost, which contains safe and acceptable levels of pathogens, is considered safe for application to food and non-food plants if contains <1000 MPN of fecal coliform per gram, and contains <1 *A. lumbricoides* egg per 4 gram. End product is considered Class B and safe soil amendment for ornamental plants if contains <2,000,000 MPN of fecal coliforms per gram.

Results showed that Class A compost was present in 35.8 % of SIRDOs after six months (Table 1). The primary mechanism for fecal coliform reduction was found to be desiccation rather than biodegradation. There was a significant correlation (p=0.008) between classification rating and percent moisture categories of the biosolid samples: drier samples had a greater proportion of Class A compost. Solar exposure was critical for maximal Class A biosolid end products (p=0.001).

Table 1. Biosolid classification at three and six months for SIRDOs.

	Classification				
	Class A %(n)	Class B %(n)	Class C [a] %(n)	Indeterminate [b] %(n)	Total n
3 months	19.4(13)	70.6(48)	6.0(4)	3.0(2)	67
6 months	35.8(29)	60.5(49)	0	3.7(3)	81

[a] Samples with fecal coliform >Class B (>2x10^6 MPN).
[b] Not able to determine class.

In addition to classifying the end product from the SIRDOs we found the following. For both the three and six-month samples the rates of *Giardia*, *Cryptosporidium*, and *Ascaris* were very high. Only 18.0 % of all samples fit into the ideal moisture content range for aerobic biodegradation. Moreover, 54.0 % had a moisture content of < 40 % and this group also had the highest percent (73.8 %) of Class A compost. Findings indicated that the reduction of fecal coliforms was primarily the result of desiccation and not aerobic biodegradation. In terms of solar exposure 78 % of the SIRDO units had solar exposure, and there was no significant correlation between solar exposure and moisture content, however 95 % of the composted samples with Class A ratings were from SIRDOs with solar exposure. In general, temperatures of the compost heaps were usually equal or similar to the ambient temperature. Results showed that 64.5 % of the units did not have a detectible odor. Almost all SIRDO users deposited toilet paper (89 %) and sawdust (96 %)

into the forming pile. We found no correlation between depositing these soak materials in the compost pile with respect to moisture content and compost classification rating.

Dehydration toilets

Between 2001 and 2002 CERM constructed and tested 20 toilets of four design types and evaluated their use over 12 months in a peri-urban community of Ciudad Juárez. This project evaluated the feasibility and impact of these sanitation systems looking at parameters such as construction costs, simplicity of design, amount of labor/time necessary for construction, and amount of land area required. In terms of impact, the sanitation systems were judged according to capacity with regards to the number of users, user satisfaction, requirements for user training, pathogenic content of composted sludge, and rating of the composted material based on the USEPA classification.

Each of the four types of ecological sanitation units were constructed based on designs already in use in different parts of the world. Impact and feasibility data were used to determine which system was the most appropriate for the El Paso/Ciudad Juárez region. These designs were variations from the model presented by César Añorve from the Centro de Innovación en Tecnología Alternativa (CITA, A.C.) in Cuernavaca, México during a site visit in 2000. The four models are

1) double-vault, dehydrating (Lasf) latrine,
2) double-vault composting,
3) single-vault dehydrating, and
4) single-vault composting.

Sixty samples were collected. Results from the laboratory analyses of the samples are shown in Table 2.

Table 2. Performance of biodegrading and dehydrating toilets over six months.

		Months			
Parameter	**Type of toilet**	**two**	**four**	**Six**	**p-value**
Moisture content	Biodegrading	47.8 (19.3)	25.2 (20.3)	20.4 (19.2)	0.07[1]
% by weight and (SD)	Dehydrating	23.3 (15.0)	7.0 (6.7)	15.8 (21.9)	0.07[1]
PH	Biodegrading	7.9 (0.4)	7.5 (0.5)	7.3 (0.5)	0.18[1]
mean and (SD)	Dehydrating	10.1 (1.7)	9.8 (1.5)	9.7 (1.5)	0.80
F. coliforms log_{10}	Biodegrading	7.3 (0.4)	6.4 (0.9)	5.5 (1.2)	0.001[1]
CFU/100 ml	Dehydrating	7.0 (0.7)	6.3 (0.9)	5.5 (1.1)	0.02[1]
mean & (SD)					
Giardia positive	Biodegrading	100 (6)	100 (6)	83.3 (5)	0.35[3]
% and (No.)	Dehydrating	100(13)	84.6 (11)	61.5 (8)	0.07[3]
Crypto positive	Biodegrading	66.7 (4)	50.0 (3)	50.0 (3)	0.80[3]
% and (No.)	Dehydrating	46.2 (6)	23.1 (3)	0.0	0.03[3]

Notes: [1]ANOVA, [3]Fishers exact test

There was a statistically significant difference over time in *Cryptosporidium* detected in the dehydrating system ($p=0.03$) compared to that of the biodegrading system ($p=0.80$) after six months (Table 2). This dramatic decrease was probably the result of the added lime, which increased pH in the dehydrating system. After six months, both the biodegrading and dehydrating systems had the same level of fecal coliforms, 5.5 (i.e. $\log_{10}$ number of CFU/100ml=5.5, Table 2). In both systems, the level of fecal coliforms present at two months was approximately halved by six months. This reduction was probably the result of desiccation rather than biodegradation or high pH, since the moisture content was low in both systems. Both the biodegrading and dehydrating systems had statistically significant differences in fecal coliforms over time, with $p=0.001$ and $p<0.02$, respectively.

In general, waterless toilet users were very satisfied with their new toilets regardless of the type. A feature that users considered important was the absence of flies and odor, which was an improvement on their previous pit latrine system. With respect to single versus double vault design, the double vault system provided a clear and undisturbed separation of biosolids in the second chamber during the four-month treatment. The double vault also provided more room for the installation of the urinal in the dehydrating toilets. Disadvantages of the double-vault design were a slight increase in cost and a larger site required for construction.

Based on the micro-organism indicators used, the dehydrating system worked better, especially for treating *Cryptosporidium*. When all parameters (moisture content, pH, and micro-organisms) were considered, the better choice for treating biosolid waste in this study area was consistently the dehydrating system over the biodegrading system.

Expanding our effort

In addition to the two pilot projects (300 pre-fabricated SIRDOs and 20 on-site built waterless toilets) close to 100 double vault dehydration toilets have been built in partnership with CMT in eight different neighborhoods of Cd. Juárez. With CMT, we have also built grey water filters (close to 20) and hand washing systems (more than 200).

Since October 2002 our intent has been to implement projects with a more holistic approach. We have combined other environmental topics such as drinking water and hygiene; recycling; pesticides and hazardous products; with ecological sanitation into multiple interventions as funds allow us to do so. Our focus is to design interventions that respond to a broader range of needs that most of the times are related to the lack of piped water and sewer services.

CERM has developed many educational materials that have helped to transmit information in a very effective way. These materials have been designed in a simple and funny format so that readers find them entertaining and learn the message at the same time. Results from surveys and observations on the effectiveness of these materials show overwhelming acceptance by the public. Not only did they like the format and content but when asked a specific question about the recommendations given in the story books, 96 % of the participants answer correctly.

Currently, CERM is working on an impact evaluation of the hand washing systems and the grey water filters. Preliminary results show that both systems are very well accepted by the residents. These units cost about $15 USD for the hand washing systems and $225 USD per grey water filter. Unfortunately people in need of these items usually can not afford any of them.

DISCUSSION AND RECOMMENDATIONS

From our research projects we learned that the dehydration toilets work better for our arid region. We have also learned that regardless of the technology being promoted, training, education, and follow up are extremely important and key to the success of any intervention. All of our interventions have been more or less successful proportionally to the educational component involved.

Below is a list of recommendations that we believe have been beneficial for implementing our projects:

- Let beneficiaries get involved as much as they can (labor, time, resources) throughout the process of construction/installation
- Provide technical assistance at all times
- Monitor beneficiaries’ maintenance and suggest corrective actions on time
- Have a strong educational component plan for the long run
- Be flexible
- Bringing volunteers on board creates a powerful synergy giving everyone involved a sense of accomplishment and satisfaction for assisting people in great need
- Measure your success or failure. Funding organizations usually need numbers to support your next project.

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REFERENCES

1. United Nations Conference on Human Settlements. *Habitat II, dialogue III: water for thirsty cities*. *UN Conference on Human Settlements*. Istanbul, Turkey. 1996.
2. Esrey, S *et al*. *Ecological Sanitation*. Sida, Stockholm, 1998.
3. INEGI (muestra del Xll Censo General de Población y Vivienda, 2000).
4. Cech, I. and A. Essman. *Water sanitation practices on the Texas-México border: Implications for physicians on both sides.* Southern Medical Journal, 85(11): p. 1053-64. 1992.
5. Pan American Health Organization. *Border health statistics*. 1993.
6. City of El Paso, Department of Planning Research and Development. *The Plan for El Paso,* 1988: El Paso, TX.
7. Redlinger, T., *et al*. *Seroprevalence of Hepatitis A and Hepatitis E among low-income pregnant women in a US-México border community.* Texas Medicine, 94(5): p. 68-71. 1998.
8. Redlinger, T., K. O'Rourke, and J. VanDerslice. *Seroepidemiology of Hepatitis A among school children in a USA-México border community.* American Journal of Public Health. 89(9): p. 33-35. 1997.
9. Esrey, S. *Water, waste, and well-being: a multicountry study.* Amer J Epidemiology 143: 608-23. 1996.
10. USAID. *Health benefits from improvements in water supply and sanitation: survey and analysis of the literature on selected diseases.* Water and Sanitation for Health Project Technical Report: No. 66. 1990.