

Use of Appropriate and Affordable Technology for Water Quality Improvement in a Community Managed Water Supply Demonstration Project in Phnom Penh, Cambodia

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Abstract

Water supply is a major problem that local authorities find difficult to handle. Communities in peri-urban areas are often not served by the municipal systems due to limited capacities of local authorities. This paper presents the experience and lessons gained in implementing a community-built and managed water quality improvement demonstration project in Phnom Penh, Cambodia. The project attempted to demonstrate that clean water can be supplied at an affordable price to the urban poor, by adapting appropriate technologies and a participatory development process. The project used simple technology that ordinary people can understand to treat rain water harvested in an earthen pond. Ferro-cement technology was used to construct most components of the treatment system in order to be cost effective. The selection of these two technologies enabled to construct the system within a limited budget. The project also demonstrated that tapping of latent social capital can make community projects of this nature feasible. The output results of the project show that harvested rainwater with high turbidity can be treated to acceptable standards using appropriate technology. The outcome results show that project could significantly reduce physical and financial burden on people. The paper also outlines the measures taken to ensure the sustainability of this demonstration project.

Keywords: Appropriate technology, rainwater harvesting, change agent, community mobilization, social capital

Introduction

Safe and clean water is a basic need for living. However, many local authorities in developing countries are unable to provide safe drinking water for every citizen. Currently more than 1.1 billion people in the world lack access to safe water (World Bank, 2008). While people living in rural areas can rely on natural water sources to meet their fresh water demand, people living in urban areas face serious problems if they cannot afford to buy water from service providers. This problem is even more acute in peri-urban areas where there exist no municipal water distribution systems. People living in such areas have to rely on water transported by vendors or surface water sources such as rivers and canals or ground water. It is very commonly observed that both surface water sources as well as ground water in peri-urban areas are contaminated by agro-chemical residues. This is especially the condition of rainwater that is harvested from fields and stored in open ponds.

In South-East Asian countries rain water harvesting for domestic use is a traditional practice. People have been using large clay jars or earthen ponds to store harvested rainwater. Clay jars have been replaced by cement jars with the developments in Ferro-cement technology. This technology is used not only for making traditional shapes of jars but also for cylindrical jars with bigger volumes for storing and supplying water. However, there is not much attempt to use the Ferro-cement technology¹ for water treatment systems. Instead, the conventional reinforced cement-concrete (RCC) technology is often used even in small scale constructions. RCC constructions are inherently very costly and therefore unaffordable for communities and households who want to improve their water treatment systems. Therefore, community built water treatment systems require less costly yet appropriate construction technologies and treatment systems.

This paper presents the lessons learnt in adapting Ferro-cement technology to construct a community built and managed water supply system in a poor suburban community in Phnom Penh, Cambodia. This initiative was implemented as an alumni demonstration project under the South-East Asia Urban Environmental Management Applications (SEA-UEMA) Project, which is a partnership project between the Canadian International Development Agency (CIDA) and the Asian Institute of Technology (AIT), Bangkok. The demonstration projects component of the SEA-UEMA Project intends to demonstrate three ideas.

1. Involving alumni of AIT as Change Agents for improving urban environmental qualities.
2. Adaptation of appropriate technology and transfer of knowledge for community based environmental management initiatives.
3. Mobilizing communities for finding solutions for their environmental problems through a participatory process.

The demonstration project in Phnom Penh was implemented by Mr. Abdul Rashid Khatri, a graduate of the Human Settlements Development Program of AIT. He is attached to an NGO in Phnom Penh. Ms. Va Dany, an Environmental Engineering graduate of AIT and a faculty member of the Royal University of Phnom Penh, provided technical expertise for designing the water treatment system. Dr. Kyoko Kusakabe, a graduate of the Gender and Development Program of AIT and a faculty member of AIT, served as the gender expert. The author of this paper, who is also a graduate of the Urban Environmental Management Program and a faculty member of AIT, acted as the coordinator of this team of change agents.

The demonstration project was implemented in the Tropeang Chork Community, which is located 24 km from the city center in the Sangkat Prey Veng in Phnom Penh. Although this community is located in the area of jurisdiction of Phnom Penh Municipality, no municipal infrastructure network has reached there yet. Even the access road that passed the community

¹ Ferro-cement is a composite material which consists of cement, sand, and wire mesh as reinforcement. A Ferro-cement structure can be as thin as 2-5 cm, much thinner and lighter than poured concrete structures. Because it has wire reinforcing distributed throughout the structure, Ferro-cement structures have equivalent tensile strength with ordinary concrete but have higher flexibility. It has comparable tensile strength with concrete structures as required for water tanks. For certain types of structures, a cost comparison between Ferro-cement and RCC is about 1:2. This is a significant cost saving for limited budget projects and other low-cost constructions. Different with conventional concrete structures which require high skilled labor, Ferro-cement structures do not need skillful labor to build. With this advantage, Ferro-cement structures can be constructed in remote areas utilizing available unskilled local labor. However, a skillful technician should oversee the construction process (Nedwell and Swamy, 1994).

was a dirt road at the time of launching the demonstration project. Presently it is macadamized. It will take more time for other basic infrastructure such as water supply to reach the community.

The community used to meet its water needs in different ways. During the rainy season people collected water from the roofs and stored it in ferro-cement containers (jars or cylinders) for future use. During the dry season some people brought water from a pond that is located about 1.5km away from the community. That water was used for domestic purposes and they bought drinking water from a vending truck which came to the community from time to time. When a road improvement project funded by a local NGO called Urban Resource Center (URC) dug a pit to obtain soil, a pond was automatically created where the community could harvest rain water. However, water in the pond is muddy and full of silt. The above mentioned demonstration project funded by the SEA-UEMA Project was initiated to implement a treatment system that is not only affordable and manageable to the community but also effective in removing silt and other impurities from raw water drawn from the pond. Moreover, the team of change agents who initiated the project faced the challenge of organizing the community to collectively operate and manage the system on a cost-sharing basis. Cost sharing was essential to deliver clean water to households at a price lower than that of itinerant water vendors. Therefore, as a demonstration project it was a multi-faceted one to showcase; (1) an appropriate water treatment method, (2) an affordable method of construction, (3) a participatory planning and management process and, (4) a cost reduction and cost sharing mechanism. This paper briefly deals with all these demonstrative aspects of the project.

Plate 1 : Sources of Water before Implementing the Project



Harvested Rainwater in Jar



Pond



Water Vendor



Ground Water from a Hand Pump



Brought by Cart from the Pond



Collection from Roof and Vendor

Community Mobilization

Tropeang Chork Community has a total of 106 households and a population of 527. The average monthly income of a household is around 200,000 Riel (≈ 50 USD). People are

engaged in casual work, small businesses, motorcycle taxi operation and rice cultivation. Lack of water supply and sanitation facilities are the most acute problems that the community face. During the rainy season, most people (59%) harvest rainwater from the roofs and some others (24%) utilize pond water for domestic purposes. Others extract ground water using a hand pump installed by a project funded by JICA. During the dry season, 96% of the households depend on water vendors for drinking water. The price of water is about 8,000 Riel (2 USD)/m³ and the source of that water is unknown. The majority of households utilize water brought from a pond for domestic purposes during the dry season. This pond is located about 1.5 km from the community. Carrying water from the pond to households is a burden, especially for men. Water for about 80% of the households is brought by men using push carts or motorcycles. It takes about 1 hour to fetch water from the pond and bring to the community.

Therefore, bringing safer water closer to the community was the major idea of the demonstration project. With this idea, a treatment plant to treat rainwater harvested in the new pond and a distribution system was envisaged. The newly excavated pond is located within the community. Since it is newly excavated, the harvested water in the pond was very muddy. Mr. Khatri, the project implementer, could successfully negotiate with the community and the SEA-UEMA Project for a collaborative intervention to treat and distribute water obtained from this pond. The SEA-UEMA Project agreed to provide financial contribution of 10,450 USD and technical support (through an environmental engineering expert, environmental management expert and a gender expert) and the community agreed to contribute land to install the treatment plant and labor for construction. The community also agreed to install a distribution pipe system from the treated water storage tank to individual households, once the treatment system is completed. The project implementer could also obtain some financial contributions (3,050 USD) from several NGOs, another community development project and a trust fund.

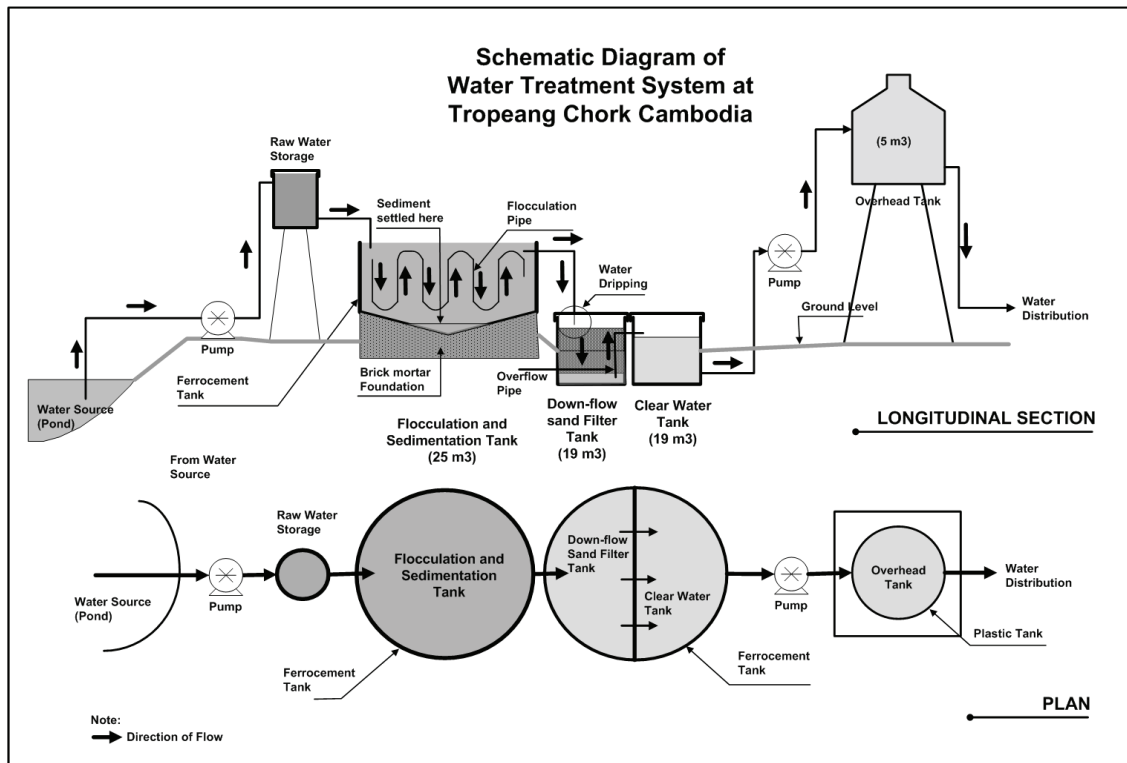
The main activity of the project was designing and construction of the water treatment plant. The team of change agents faced three challenges in designing the system, (1) How to treat harvested rainwater which is contaminated with coli-form and with high turbidity, (2) How to design and construct a treatment system within the available budget, (3) How to design a treatment system which is simple for the community to manage by itself.

The initial design showed that cost of construction using Reinforced Cement Concrete (RCC) will greatly exceed the available budget. Therefore, it was decided to use Ferro-cement technology to reduce the cost of construction. Initial calculations revealed that the cost of construction can be reduced by 50% if ferro-cement is used. Since there was no precedence existed to explain this idea to the community, a scale model of the designed system was built involving some community members. Technical assistance for this was obtained from a local NGO that had some experience in Ferro-cement construction. This was useful for the community members involved in the project to understand how the chambers for coagulation-flocculation-sedimentation and filtration work, and also getting hands-on training on Ferro-cement construction. The model was also useful to build confidence among the community members. There was some pessimism at this stage about the ability of the system to treat the muddy water obtained from the pond into clean water. A workshop was conducted involving both men and women to introduce them how the system works and its potential to reduce their burdens. Since women are the major handlers of water at the households and men are mostly

responsible for fetching water, participation of both genders in the action planning process was very important.

Application of Ferro-Cement Technology for Components of the Water Treatment Plant

The water treatment system consists of the components as shown in the diagram below.



Coagulation, Flocculation and Sedimentation Tank: Raw water with silt is pumped from the pond to this tank through a storage tank. In this tank, water is passed through a coiled perforated pipe that runs vertically up and down along the wall of the tank. A coagulant (alum - Al_2SO_4) is added to raw water in this pipe to enable the flocculation process which works on the principles of 'hydraulic mixing'. Once passed through the pipe, water is retained in this tank for few hours allowing the sediments to settle down at the bottom. The tank was made out of Ferro-cement using a cylindrical shape with the dimensions of 4.0m in diameter, 2.0m in height with 8cm in thickness. This was placed on a 0.7m high base to create a gravitational flow.

Aerator: Air affects water chemically and physically. This fact was explained to the community and used in the project. The water coming from the sedimentation tank was set to pass through a set of perforated pipes and drip into the Filtration tank while aerating water in the process.

Slow Sand Filter and Clear Well: The aerated water passes through a slow sand filter to remove the remaining particles in water. Slow sand filter is a simpler technology that the community can easily manage by replacing upper layer of sand from time to time instead of backwashing sand that is technically more sophisticated. Additionally, the design of the filter has provision to maintain a continuous layer of water on top of the sand layer to prevent any growth of algae on sand. The filtered water is collected in a clear well where Chlorine is

added to destroy any remaining bacteria. The clear well also serves as the ground storage tank before pumping to the over-head tank for distribution. The filter chamber and clear water storage chamber was attached in a single tank to economize on the cost. This was also constructed using Ferro-cement with the dimensions of 5.0m in diameter, 2.0m in height and 8cm thickness.

Overhead Tank: Water from the Clearwater storage tank is pumped to the overhead tank. This tank serves as the hydraulic head provider for water distribution through a gravity system. A RCC structure having 5.0m height was constructed to place a heavy duty PVC storage tank. This is the only major element of the system that did not use Ferro-cement technology. There was no expertise available in Cambodia to construct an overhead tank using Ferro-cement.

Water Meter and Distribution Point: This part is installed at the bottom of the overhead tank to distribute water and measure the quantity of water sold to the consumers.

Plate 2 : Water Treatment System



New Rainwater Harvesting Pond



Water Treatment System



C.F.S. Tank and Slow Sand Filter

Capacity Building

A series of trainings/workshops were conducted involving both men and women of the community, throughout the participatory planning and implementation process. This included;

- Visit to community water supply projects in Kandal Province (20 people - 3 Female)
- Training on Ferro-cement construction (7 people, all male)
- Training for the maintenance team (4 people, all male) on Jar Test, use of alum and Chlorine
- Training on maintaining the sedimentation tank and slow sand filter
- Training on user charge collection and accounting to financial management committee (4 people - 2 Male, 2 Female)

In addition to the above, 10 community meetings were held during the community action planning process with average participation of 44 females and 60 males. These were useful in collective capacity building for shared decision making.

Output Results

The total water demand of the community is 28.6 Cum/day as per the baseline survey. The water treatment plant was designed to produce 30 Cum/day but it yielded only 25 Cum/day at the initial period of operation. This was attributed to the high turbidity level of the input water. Water quality tests on input and output water showed following results.

Table 1. Result of Water Quality Test

Parameters	Unit	Standards		Water Quality	
		WHO	MIME	Raw Water	Treated Water
Iron	mg/liter	0.1 – 0.3	0.3	4.4	0.16
pH	-	6.5 – 8.5	6.5 – 8.5	7.3	7.1
Turbidity	NTU	<5	<5	514	4.2
Total Hardness	mg/liter	<100	<300	54	18
Total Coli form	CFU/100 ml	0	0	12,000	0
E-coli	CFU/100 ml	0	0	5,040	0
Salmonella	CFU/100 ml	0	0	20,000	0

The quality of treated water meets both WHO and MIME (Ministry of Industry, and Mining and Energy, Government of Cambodia) standards, and therefore it is safe for drinking and cooking.

Outcome Results

Following outcome results were revealed at a follow-up community meeting.

Table 2. Indicators of Improvements

Aspect of Improvement	Condition before Project	Condition after Project
Ave. distance travel to fetch water	1.5 km	200m
Average time spend to fetch water	One hour	Twenty minutes
Frequency of fetching water	Once in a day	Two times in three days
Transport mode used	Push-cart/motorcycle	Push-cart/motorcycle/walk
Average price paid for water	USD 2.17 per Cum	USD 0.5 per Cum
Perception on water Quality	Poor, unsafe for drinking	Good, safe for drinking

The follow-up meeting also revealed some other outcome results. The close location of the system to the community lessened the workload of both men and women. Although the share of workload has not changed among men and women after the project since they still have to carry water to homes, their burden has reduced due to the closer location of the new source of water. This will further reduce when the community accumulates enough funds from water vending and savings to install community stand points first, and individual household connections later. The community collectively decided to fix the water tariff at USD 0.5/Cum. This has reduced the financial burden of the households, since they used to pay more than USD 2/Cum for water brought to the community by a vending truck. As a demonstration project the most significant outcome result of the project is the revelation of social capital available in the community to invest in a community enterprise. People's voluntary participation in planning and implementing this community project and their contribution of a piece of community owned land (4,200 sq m.) for the water treatment plant and labor for construction indicated their willingness to invest their social capital. If these contributions are valued in monetary terms, their share is about 80% of the total project cost. However, it was the financial contribution of the SEA-UEMA Project and the interventions by change agents to mobilize the community that triggered the outflow of this social capital.

Sustainability of the System and Challenges

Sustainability is a critical issue in any project intervention. Sustainability concerns already exist in this project after nearly two years of operation. The output level has come down to 15 Cum, that is 50% of the designed capacity. There are two interconnected reasons behind this. Firstly, the high turbidity of input water has clogged both flocculation coil and the slow sand filter. Secondly, the maintenance team has failed to regularly maintain the system due to their livelihood related priorities. Especially during the farming season they have not been able to attend to the maintenance work. Moreover, water is not a scarce resource during the rainy season. People can rely on rainwater harvested from their roofs. This has led to reduced demand during the rainy season, which has disappointed the project management team. People in the community are also losing the confidence by seeing the gradual reducing of output efficiency of the system. They perceive that the system cannot meet the total water demand of the community. Therefore, they are reluctant to contribute to the community saving fund to install the water distribution system. In order to address these problems, an additional tank for coagulation-flocculation-sedimentation is being constructed using further funding support (USD 11,570) from the SEA-UEMA Project. This tank uses a baffle system for flocculation, instead of the previously used coil system. This decision was taken based on the lessons learnt by monitoring the functioning of the first sedimentation tank. It is also expected to reinstall the slow sand filter using new media to increase its efficiency. Alum is periodically added to the raw water pond to reduce the turbidity of input water. Banks of the pond were consolidated to prevent erosion of the banks and silting water in the pond. Trials are being carried out to identify suitable aquatic plants and ground covers that can reduce the silting of water in the pond. The biggest challenge still remain is the generation of adequate funds to construct the distribution system. Until then, people have to come to the treatment plant to buy water.

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