Research Report
On
Water Purification System

Habitat for Humanity International-Bangladesh

Dhaka HRC (North) Office

13/Ka/1 (2nd floor)

Police line, Jail Road

Mymensingh-2000, Bangladesh

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Md. Mahfuzul Haque

Research Officer (WaSH Project)

Acronyms	
ART	Arsenic Removal Technology
BCA	Bangladesh Country Almanac
BOD	Biological Oxygen Demand
BUET	Bangladesh University of Engineering and Technology
CAP	Community Action Plan
CBO	Community Based Organization
CI	Corrugated Iron
CIM	composite iron matrix
COD	Chemical Oxygen Demand
DPHE	Department of Public Health Engineering
FC	Fecal Coliform
FGD	Focus Group Discussion
GIS	Geographical Information System
HFHI-B	Habitat for Humanity International
MS Rod	Mild Steel Rod
NGOs	Non-government Organizations
PNGO	Partner Non Government Organization
PVC	Poly Vinyl Chloride
TC	Total Coliform
WaSH	Water Sanitation and Hygiene
WHO	World Health Organization

Abstract

Communities in the study area lack clean water and compel to use unprotected source of water. In these areas contaminated water has a significant impact on health status. But efficient and cheap water purification systems can make easy access to clean water a reality. We have designed a water purification system for the study area. Before the design process, we reviewed documents from Engineers and different organization for ideas and proper procedures. The community requires an effective and economical process to purify local underground and surface water. In our design we considered common underground and surface water contaminants i.e., iron and arsenic. On the other hand for the pond water the problems of algae and other contaminants have also been taken into consideration. In designing the system, we considered maintainability, cost-effectiveness, and accessibility to local resources. Our design consists of a slow pond and sand filter (Bio sand filter) to remove turbidity problem as well as arsenic and iron. We constructed a prototype design using readily available and easily accessed materials such as brick, PVC, plastic, sand, and gravel. These resources are chief, available and community people area more acknowledged with the filtration system. Most often they use it in the household level to reduce iron in their existing tubewell water. So it is presumed that a structured and effective system that is demonstrated in Durgapur will create a chance to reduce water related problem in the community. Testing our prototype using local river water, we will be able to find appropriate and structured and cost effective water purification system for the community.

Chapter I: Introduction and Background

1.1 Forward

Water can be unsatisfactory without being unsafe; therefore, filtration and some form of disinfection is required for treatment if the water is to be used for daily activities like drinking, bathing, brushing teeth, or cooking. Water, Sanitation and Hygiene promotion Project is funding by AUS AID and implementing by Habitat for Humanity International-Bangladesh, with a broader objective of reducing water related problems by providing safe water, sanitation facilities to the communities and improving their hygiene behavior. Research to find proper water supply options is an important aspect of the project which aims to provide safe water and free from physical, chemical and biological contamination more specifically Iron and arsenic free water and reduce the use of pond water. Water supply in the study area is primarily dependent on low cost tube well technology. But identification of iron and arsenic in ground water appeared as a threat on the ground water based water supply system.

Safe water supply is a challenge especially in the rural communities of Mymensingh, Madhupur and Durgapur. Concentration of iron and arsenic in ground water makes the water dangerous for health and the community cannot escape from the danger. Sometimes the scarcity of water and seasonality of water force the rural people to use the pond and river water. So access to safe water for drinking is one of the basic needs where no piped water system persists.

1.2 Background of the study

In the study area household depend on the tube well water for their day to day activities. Unavailability of safe water most often degrades their level of standards for living. The study area has agriculture based economy especially in Madhupur 27.75% and in Durgapur 28.64% household directly depends on agriculture so huge pressure on water for irrigation cause lowering the ground water table during the months of September to March. During this time people of the areas have to suffer a lot due to lowered ground water table. Further many tubewell contains excessive iron and arsenic. It is also important to note that many households do not have their own tubewell. In the baseline survey report it is found that more than 10% household have to travel more than 150 feet to 500 feet to fetch water because most of them do not have their own tubewell or their tubewell possess excessive iron or arsenic. In search of safe drinking water, household members collect water from neighbor's house travelling from their own house and most of the cases the water becomes contaminated during water howling or during water collection due to unsafe water carrying container or jar. Sometimes the girls and boys area engaged to collect water that consumes their important time of school going or

preparing their study. Even water collection produces strain on body of women as they are most often engaged in water howling activities. Considering all the dynamics HFHI-B aims to

- Research on water purification system for the community and
- Demonstrate water purification system using locally available and low cost materials considering the physiographic condition.

During the FGD and field observation it is found that the study area has complex water sources in terms of geology as well as physiography. Further, protected but safe surface water source is not available in many parts of the area. So, one technology (Rain water harvesting) may not be suitable for the larger areas because of different hydro geological situation.

1.3 Study area

The study area covers selected union of Mymensingh, Madhupur and Durgapur. The details of the study area are listed below:

1. Mymensingh: Mymensingh Sadar, Aqua, Gohailkadi, Dhapunia and Khagdohor.
2. Madhupur: Aronkhola, Aushnara and Madhupur Sadar.
3. Durgapur: Chondigor, Kakoirgora Durgapur Sadar and Durgapur Municipality (Birisiri).

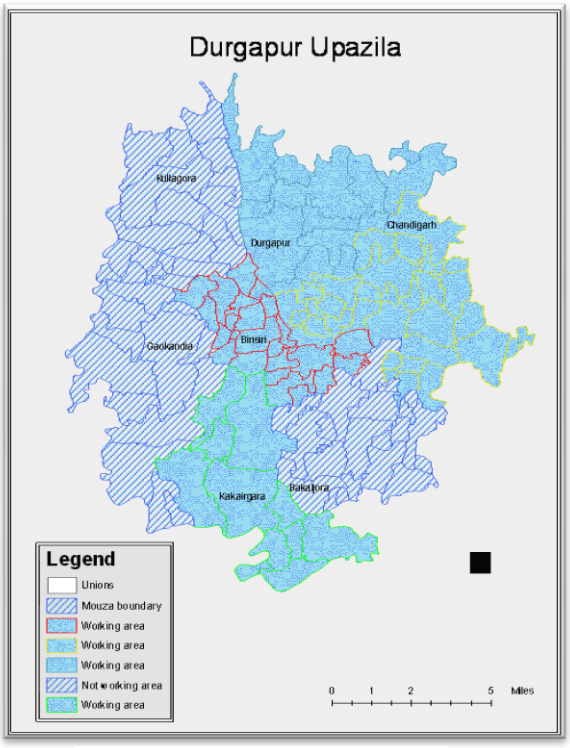


Figure1 Study area (Durgapur)

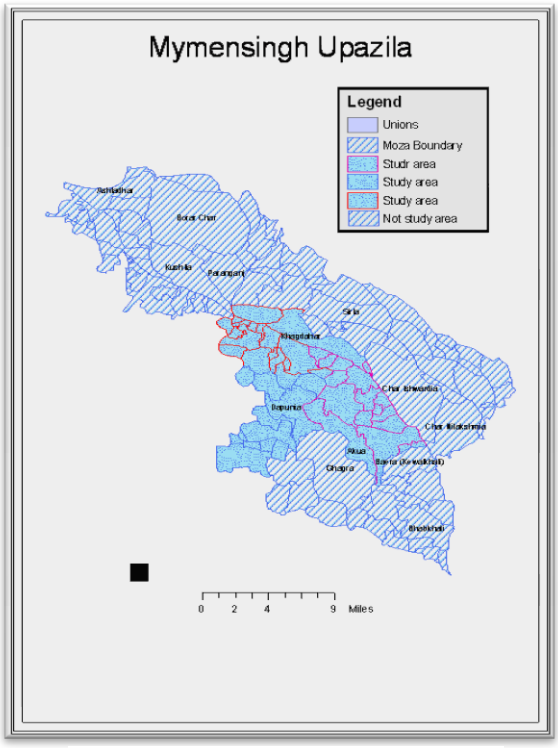
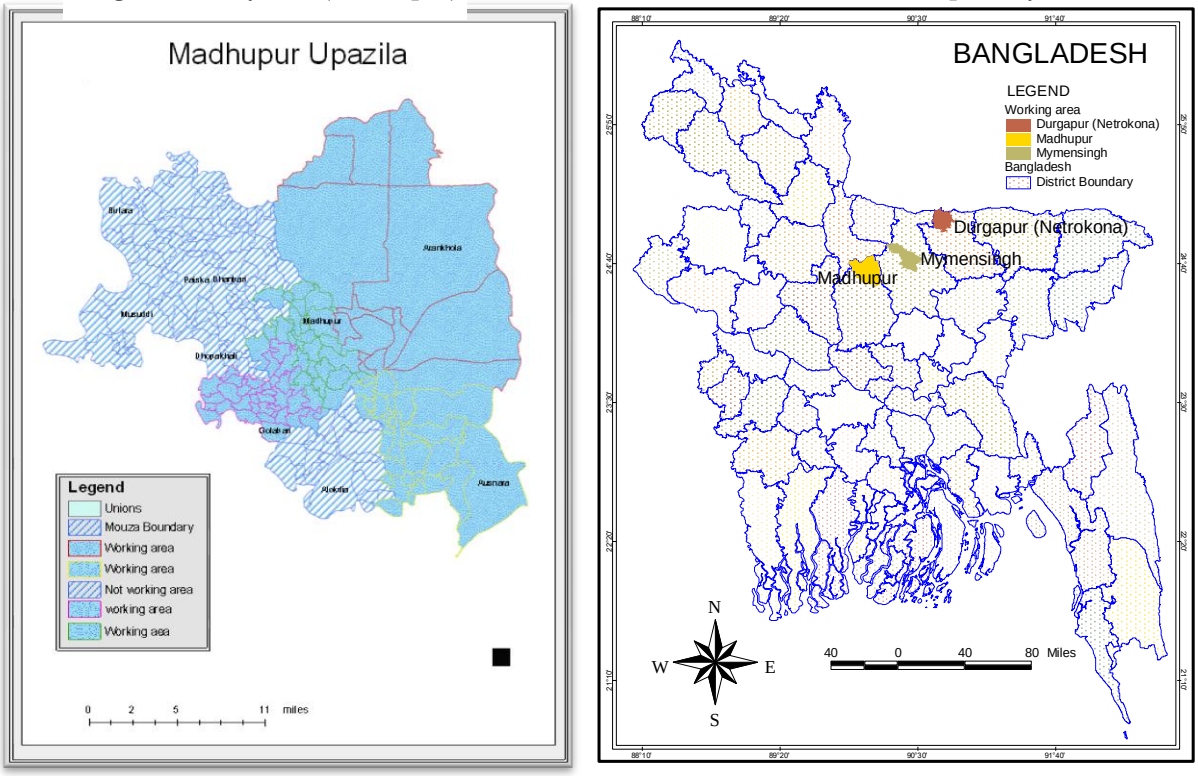


Figure2: Study area (Mymensingh)

Figure 3: Study area (Madhupur), **Source: BCA Database, compiled by Author, 2011**



1.4 Aim and Objective of the research

The broader aim of the research is to find out appropriate water purification system in the study area. Concerning the main aim the objectives of the research was:

- Find out the water related problems of community.
- Identification of existing water purification technology in the study area.
- Formulate a uniform or area wise water purification technology based on problem as well as physiography.

1.5 Methodology

The study aims to find out new and innovative approaches in the study areas for the appropriate water purification system that can ensure supply of safe water to the community. During the study time 12 FGD have been conducted in project areas of Mymensingh, Madhupur and Durgapur Upazila. The study maintained proper procedure of data collection from the field. The total study involved with collection of information from primary sources as well as secondary sources.

1.5.1 Primary sources of data

The main sources of primary data are

- **Focus Group discussion (FGD):** FGD with community people, community leaders and Partner NGOs provide the main source of data. FGD is done to understand about community knowledge about water purification system. FGD work has enhanced the authenticity to perceive households ideas and their opinions about water purification system.
- **Lab analysis of water quality:** Laboratory analysis of water quality is done in three different study areas of Mymensingh, Madhupur and Durgapur. Sample of water is collected form Dhapunia union of Mymensingh, Chandigar Union of Durgapur and Goshaibar of Madhupur union. Water is tested from BUET using different methods of analysis as per the standard protocol. From each area two types of water is collected;
  1. One is tubewell source and (Underground water source)
  2. another one is pond water (surface water source)

Tubewell water sample is collected from the community which is used by a group of household for drinking. On the other hand surface water source or pond water sample is collected from the study area which is used by the group of community for bathing, cooking, washing and for day to day activates. During the selection of water source the physical observation is made to know the surrounding environment of the pond or tubewell. This observation has given important insight to analyze the data of water sample.

- **Collection of baseline information:** baseline information is primarily used to identify the areas where the problem exists. From the baseline information water related need of community is justified.
- **Direct observation:** by direct observation we got the real picture about the impact of the phenomenon for understanding the problems and opportunities of water purification system. The data is documented and used for context analysis. On the other hand Visits to villages where indigenous technologies area used for water purification (including transect walks, group discussions, and interviews with individual household members).

Further Interviews with key informants on rural water issues, interviews with local government officials and Interviews with the partner NGO staff of the water and sanitation program gave important information which is used in data analysis.

1.5.2 Secondary sources of data

Secondary information mostly collected from the web documents. Based on basic information, a desk review and context analysis is done for primary identification of water purification technology for the particular area.

1.6 Data analysis

Data analysis is done by using different tools. For the spatial analysis ArcGIS 3.2 has been used. On the other hand the statistical data has been analyzed using the Microsoft Office Excel and SPSS. Systematic and appropriate solution of existing problem is drawn by Matrix and context analysis. Close observation was also an important method for understanding the dimension of problem and its solution.

1.6.1 Literature review

Purified water is essential to living a healthy life as such; everyone should have access to it. As part of our attempt to make clean water easily accessible to rural communities of Mymensingh, Madhupur and Durgapur. One of the major objectives of our Study is to find water purification options for the community that will be using. Different types of water purification and disinfecting system is found in different part of the world. Rafael Bravo and his team worked with the Rutgers' Chapter of the Engineers in designing a water purification system and constructing a prototype for rural Thailand. The ultimate goal of the study was to find water purification system the villagers in Thailand. They developed four types of water purification system they area Cascade Step Drop, Cloth filter, Slow sand filter and prototype water purification system using the easy accessible materials. The types of treatment units most commonly used to filter pond or unprotected water to remove sediment, in consort with either an ultraviolet light or chemical disinfection. There are different types of water purification system in Bangladesh which are installed in household or community level. The systems mostly developed and used in Bangladesh works by the name of boiling of water, domestic filter unit, and water filter candles etc. all the systems area inexpensive and can provide portable water in the house. Sono arsenic filter locally known as "3-kolshi" system is used in rural part of Bangladesh. The system use three pitcher arsenic filtration systems and can reduce iron form water. This system was first developed in 1999. In 2001 the system was updated by Prof. Hussam and Dr. Munir. The filtration system was mass produced and used by many people. It is noteworthy that there is controversy on their arsenic waste disposal system (SOS-arsenic.net last accessed 03.05.2011). Further Bangladesh government has implemented these types of program by the help of UNICEF. They have developed union wise technology mapping to support the

community for preparing their Community Action Plan (CAP) and selected the suitable water option. Under these initiatives DPHE Ground Water Circle prepared union wise technology mapping based on the available hydro-geological data. On the other hand National Policy for Arsenic Mitigation 2004 and Implementation Plan of Arsenic Mitigation in Bangladesh suggested implementing the technologies of Dug/Ring Well, Pond Sand Filter, Deep Tubewell, Rain Water Harvesting as promotional option and Arsenic Removal Technology (ART) to provide arsenic and iron free water in rural communities of Bangladesh (DPHE, 2008).

During the study it is identified that water purification and infiltration system remove pathogens and microorganisms from water. The system also removes bacteria, virus and other contained particles like iron and arsenic. Health impact studies estimate a 30-47% reduction in diarrhea among all age groups, including children under the age of five, an especially vulnerable population (Sobsey, 2007; Stauber, 2007). It is also found that disinfecting rate depends on the purification system and regular management of the system. In a study it is found that Bio sand filter could achieve a 42% reduction in diarrheal disease and ceramic filters could achieve a 49% reduction in diarrheal disease (Sobsey, Mark D, 2006) Based on slow sand filter research, the bio sand filter may also remove some heavy metals (Muhammad, 1997; Collins, 1998). There is also a design modification known as the KanchanTM Arsenic Filter, that is effective in removing both pathogens and 85-90% of arsenic from source waters (Ngai, 2007).

Chapter II: Assessing the problem and analyzing the options

2.1 Problems found in the study area

To understand the problem of the study area FGD and physical observation has been made. Form the FGD it is found that diarrhea and skin disease is most prevalent. Deteriorated surface water and iron in drinking water is the main reason of skin disease. People using the ponds water for bathing, washing and other activities and the ponds area not protected and the high level of Fecal Coliform (FC), Chemical Oxygen Demand (COD), Total Coliform (TC), total Hardness (CaCO3) and Algae/Chlorophyll_a is found. And the excessive limit of these physical, chemical and biological elements is the main reason of skin disease. According to WHO guideline For protection from health outcomes A level of 100 000 cyanobacterial cells/ml (equivalent to approximately 50mg chlorophyll-a/litre if cyanobacteria dominate) represents a guideline value for a moderate health alert in recreational waters. The presence of cyanobacterial scum in swimming areas represents the highest risk of adverse health effects, due to abundant evidence for potentially severe health outcomes associated with these scums (WHO, 2003).

Figure 4: Use of pond water (Washing, bathing and household purpose) and environment,
Source: Field survey, 2011

Table 1: Laboratory test result of water samples for Mymensingh, Madhupur and Durgapur

Sl.No	Water quality parameter	Unit	Bangladesh standard for Drinking water	WHO Guideline values, 2004	Concentration present in study area					
					Mymensingh		Madhupur		Durgapur	
					Tubewell water	Pond water	Tubewell water	Pond water	Tubewell water	Pond water
1	pH	-------	6.5-8.5	6.5-8.5	**6.44**	**7**	**6.25**	**6.94**	**6.55**	**6.61**
2	Color	Pt-Co	15	15	**17**	**71**	**9**	**98**	**247**	**49**
3	Turbidity	NTU	10	5	**82.3**	**23.4**	**1.84**	**60.8**	**48.3**	**16**
4	Total Hardness	mg/l	200-500	200	**166**	**102**	**76**	**94**	**24**	**54**
5	Chloride (Cl)	mg/l	150-600	250	**21**	**23**	**8**	**50**	**12**	**28**
6	Total Dissolved Solids (TDS)	mg/l	1000	1000	**206**	**182**	**133**	**191**	**108**	**173**
7	Manganese(Mn)	mg/l	0.1	0.4a, 0.1b	**0.374**	**0.031**	**0.126**	**0.047**	**0.061**	**0.018**
8	Arsenic (As)	mg/l	0.05	0.01	0.374	**0.002**	**<MDL**	**0.005**	**0.003**	**0.001**
9	Iron (Fe)	mg/l	0.03-1.0	0.03	**5.5**	**0.36**	**0.2**	**0.8**	**6.5**	**1.2**
10	Total Coliform (TC)	CFU/ 100ml	0	0	**0**	**1740**	**2**	**3320**	**10**	**1090**
11	Fecal Coliform (FC)	CFU/ 100ml	0	0	**0**	**1320**	**0**	**2320**	**0**	**600**
12	Electrical Conductivity (EC) at 25°	µS/cm	-------	--------		**331**		**350**		**250**
13	Ammonia-Nitrogen (NH3-N)	mg/l	0.5	1.5		**0.862**		**1.025**		**0.668**
14	Orthophosphate (PO4) or Relative phosphate	mg/l	6	-------		**0.077**		**0.249**		**0.435**
15	Chemical Oxygen Demand (COD): Dichromate	mg/l	4	-------		**18**		**59**		**33**
16	Biochemical Oxygen Demand (BOD5)	mg/l	0.2	-------		**4**		**18**		**6**
17	Dissolved Oxygen (DO)	mg/l	6	-------		**2.72**		**4.85**		**6.36**
18	Chlorophyll_a	µg/l	-------			**32.3**		**102.5**		**4.6**
19	Algae	mg/l	-------	50		**2164**		**6868**		**308.2**

Source: Field Survey, Lab test, 2011

The standard routine drinking water parameters test incorporates 11 types of tests. They are pH, color, turbidity, Total Hardness, Chloride, Total dissolved solids, Chloride, Total Dissolved Solids, Manganese, Arsenic, Iron, Total Coliform, Fecal Coliform on the other hand for identification of water purification option of pond water, miscellaneous physical, chemical and biological parameters of water is tested. The parameters included testing of routine drinking water parameters and Electrical Conductivity, Ammonia-Nitrogen, Orthophosphate (PO4) or Relative phosphate, Chemical Oxygen Demand (COD): Dichromate, Biochemical Oxygen Demand (BOD5), Dissolved Oxygen, Chlorophyll_a and algae. All the parameters is justified by Bangladesh standard and WHO standard.

Overall the Lab resultswhich found in the study area are described below:

- **Iron:** Excess limit of iron in drinking water in Mymensingh and Durgapur which is 5.5 and 6.5 respectively. It crosses the standard limit of Bangladesh which is 0.03-1.0
- **Turbidity:** turbidity is high in all over the study area in drinking and pond water whereas it is relatively low in Madhupur.
- **Algae in Surface water:** household use the pond for bathing washing and other activates. But it is found that the water poses the excessive limit of algae which is the cause of skin disease in the area. The standard limit of 50 mg/l algae in surface water is tolerable for health in but in the study area it ranges from 308 to 6868 mg/l. in this case it is a threat to the household who area using the pond water.
- **Fecal coliform and total coliform:** total coliform is found in Madhupur and Durgapur in tubwell water which is hazardous for health and also can cause disease. And high level of fecal coliform in found in pond water which is also dangerous for health. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material. The source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water.

During the FGD some other major problems which is found in the study area are mostly related with water scarcity and limited support from Government or Non government organization. The problems are summarized below:

- Unimproved/unstructured technology is used by the household to purify water
- Limited technological support to improve existing system inside the community.
- Low water table during dry season.

- Non-availability of protected and perennial surface water source round the year.

2.2 Effect of the problem

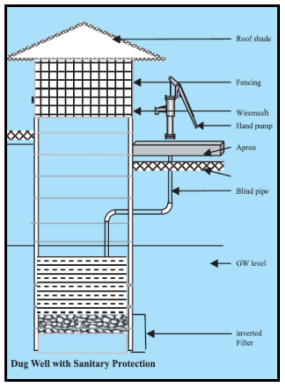
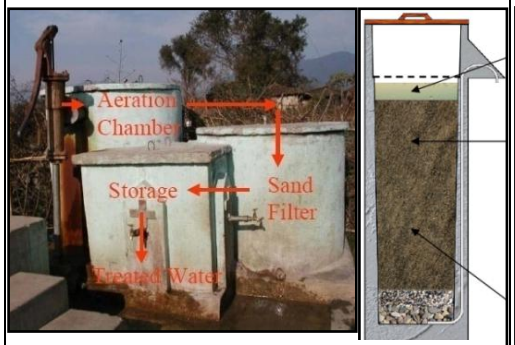
Water related problem has multiple effects on the community. According to the community people, they have to spend more time for water collection as many of their tubewell contain excessive iron. For iron free water they have to travel their neighbor's tubewell. This consumes there valuable time. Sometimes school going children fetches water for household and they become late in school. Further, use of iron contaminated water for cooking change the color of food. Community people use pond water for bathing because use of iron concentrated water damage their cloths. The cloths become useless after one or two months if they continue bathing in tubewell. So use of iron concentrated water became the cause of their financial loss. It is not worthy that the among the diseases prevalence, 19.9% skin disease is found in all over the area of Mymensingh, Madhupur and Durgapur which is the second highest after diarrheal diseases. And the cause of skin disease is due to use of unprotected surface water.

In that case the water purification technology is required to be identified on priority basis up to the study area. As it is found that tubewell water contains iron and it can be purify using Bio-sand filtration and pond sand filtration system. The most important thing is that; water does not have the major problem like arsenic though a negligible amount of arsenic is found in Mymensingh and for that arsenic removal technology or ART is a must. On the other hand, pond water can be purified by using Pond sand filtration system. Different water purification system can purify the water components like turbidity, iron, and different physical, chemical and biological components and it opens the opportunity in the area to find water purification system for the community. Further the major problems which have been found in the study area can be solved by using bio sand filtration and pond sand filtration system because most of the problems (e,g iron and turbidity) can be removed from water by using bio sand and pond sand filtration system. Regarding the options we can think to purify the tubewell as well as pond water. Considering all the possible causes and effect; the study has emphasizes on issue for providing safe water to the community of Mymensingh, Madhupur and Durgapur area.

2.3 Assessing existing water purification system in Bangladesh

There are different types of water purification system in Bangladesh. The purification system varies region to region depending on the problem. In plain land, arsenic and iron affected area the water purification system varies. On the other hand in coastal area the purification is developed mainly to purify the saline water. The system which area found in Bangladesh is described below with its advantages and disadvantages.

Table 2: Matrix water purification system and its advantages and disadvantages

Systems	Dug/Ring Well	Pond Sand Filter and Bio-sand Filter	3 kolshi system or Sono filter	ART
	 **Figure 5: Dug well,** Source: DPHE, 2008	 **Figure 9: Pond sand filtration system, Source: http://web.mit.edu/murcott/www/arseni**	 **Figure 6: Sono Filter,**	 **Figure 8: Arsenic removal technology (ART),** Source: www.sos-arsenic.net/
System appropriate for	•Areas of stony hills, Tidal zones of the costal belt.	•Arsenic and iron affected area. •Where surface water is available all around the year.	•Can be use in plain land and relatively urbanized area. •This system can be use in school to supply safe water.	•Can be use in plain land and relatively urbanized area. •Arsenic and iron affected area. •The system is feasible particularly where deep tubewell and Dug well is not feasible.
Advantages	•Free from dissolved arsenic and iron. •Water is available all around the year.	• Can purify available surface water that can be tubewell, pond or lake. •Can remove turbidity as well as biological pathogens. •pond sand filter is a good option for arsenic mitigation as well as for salinity prone areas	•Low cost and process of construction is easy. •Can use locally available materials. •Usable at household level. •These filters can produce 120 liters (at 30 liters/hour) of clean water for drinking and cooking.	• Can remove arsenic and iron efficiently. • System is reliable, easily maintainable, and socially acceptable.

Disadvantages	•Not protected and need regular maintenance. •Maintenance is difficult. •In most cases the system does not match with the community culture.	•Need to carry the water for purification that is time consuming and lengthy. •The system is installed outside the house/ in open space, so it damages frequently. •Need permanent structure and relatively expensive.	• Slow water filtration system. •Cannot purify a large volume of water. •Time consuming process. •Arsenic waste disposal system is controversial.	•High Technology specific. •Not available everywhere and costly.

Source: Compiled by Author, 2011

2.4 Assessing the community practice for water purification system at house hold level

Community people know the best about the dimension of problem and its solution. They use indigenous knowledge to cope with adverse situation. In this study, community knowledge is used to understand the problem and its solution. During the field work the practices which are found is proved to be effective and popular. So the systems area documented properly and the summary of observed practice is described in the table (Table: 3) below. In order to explore and move to forward in water purification technology and provide affordable clean water for the household that lack it, it is essential to take a set back and look at some of the ways in which water has traditionally been purified. Most of the traditional methods are cheap and sustainable, because they have been developed by the people to meet their needs, and in some cases, when integrated together; they work just as effective as the new technologies. And all the system is found in the study area. The procedure, advantages and disadvantages of the system is also described below one over another.

	Table 3: Community practice of water purification system in the study area		
	Mymensingh	**Madhupur**	**Durgapur**
System found			
Name of the system	Filth settling	3 kolshi system/ sono filter	Rapid bio-sand filtration system
Construction materials	Brick, Sand and cement	•Kolshi, •Stand made of aluminum, •Wood or bamboo, Sand, silt, stone, charcoal, iron and a tap. •Filter made of cloth other materials.	•Container made of Aluminum/tin •Wood, bamboo for stand. •Approximately 2 liters of washed ½ inch gravel, approximately 2 liters of ¼ inch of washed gravel, approximately 10 liters of washed sand •Filter made of cloth other materials.
Process of installation and work	•Make a dia of 30 inch • Ten put the mixture of cement, sand and water (Mortar) into the dia. •Take 2 days to compact the mortar. •Install in a convenient space. • Store the foul water and put it for 2-3 hours in undisturbed condition so that the dust can subside. •Then use top layer water. •Once the water finishes then clean the reservoir and fill it again.	•3 kalshi are stacked on top of each other in a stand and each Kolshi has a volume of about 18 liters. •Each kalshi has certain media and function: Top kalshi - 2 kg iron filings, middle kalshi - 2 kg fine sand and 1 kg of wood charcoal and bottom kalshi - water collection container. •A sari cloth is used as an additional filter between the top 2 kalshi. •The top and middle Kolshi has small holes which are covered with pieces of synthetic (polyester) material from inside. The holes are made for free flow junction nozzles	•Place the materials mentioned above in the container or jar. Fist place the filter/ cloth then pace the ½ inch gravel on first layer. Then place ¼ inch of washed gravel layer on it. Finally the place 10 liters of washed sand on it. •Make a bamboo or MS rod stand. •Place the jar or container on the stand.

		connected from outside. These nozzles can be easily altered to adjust flow rate. About half kilograms of small brickette pieces (grade A red bricks, 2-3 cm pieces) were spread on the clothes. The middle Kolshi is then filled with 2 kg sand (from Local River), 1 kg wood charcoal (ca. 1 cm pieces from cooking wood) and 2 kg brickette pieces. The top Kolshi has 3-kg of cast iron turnings (from local machine shop or iron works) placed uniformly on the brickette and 2 kg of sand on top of the iron turnings. All the filtering materials are pre-cleaned to remove any unwanted dirt before the filter unit is assembled. Tubewell water is poured slowly on the top Kolshi and collected at the bottom Kolshi.	
Advantages of the system	•Easy way to get turbidity free water. •can filter the big particles from the water (like sand, dust etc) • Easy to purify water. •This water can be used for flashing toilet, washing.	•Low cost-Most of the materials that go into the production of the unit can be found locally. •The unit is easy to assemble. •Although the idea is rather simplistic, the triple filtration is extremely good at removing a large percentage of the microbes that are found in untreated water.	•Easy way to get iron free water. •Low cost-Most of the materials that go into the production of the unit can be found locally. •The unit is easy to assemble. •Can be used for drinking.
Disadvantages of the system	• The system is installed outside the house/ in open space, so it damages frequently. •There is no coverage so dist particles from the air can fall into the water. •Cannot purify the dissolved bacterial pathogens form the water.	•The flow of the water is slow, only about 1 to 2 L/ hour, meaning that it is hard to generate a large volume of water quickly. •The multiple filters mean that cleaning of the filter material is frequently required in order to maximize the water flow. •The system is build of fragile materials so the probability of damage is high.	• The process of filtration is first so filtered water contain chemical particles. •Waste of time and lengthy process: Someone have to carry the water form water source and then put it into the filter jar. Then he/she have to wait until the water falls into the clean container. •Unstructured and the filter/ cloth damage frequently.

Source: Field survey, 2011

2.5 Assessing the water purification system at household level in the study area

2.5.1 Boiling

Water purification requires knowledge about the procedure. Most people know about the easiest way as boiling water and it is the most effective, very simple to carry out. Boiling water for 10 to 20 minutes is enough to remove all biological contaminants and this system is used in Mymensingh, Madhupur and Durgapur.

2.5.2 Cloth filter/Net filtration

A cloth filtration system is most common and easy way that is found in Chandigar, and Birisiri union of Durgapur. It does not produce completely clean water, but is able to significantly reduce the concentration of pathogens in the water. In 2003, researchers found that this simple filtration technique could half the number of deaths caused by cholera, during the monsoon season in Bangladesh (Meng et al., 2000). The filter is able to remove plankton from the water, which cholera symbiotically lives on. The sari filters are able to remove sediment and any microorganisms that are larger than 20 microns and tests have shown that 99% of cholera can be filtered out by a sari that is folded four times (Neiln *et* al.,2002)

Figure 5: Cloth filtration system, Source: Field survey, 2011

The community use this system to clean the water collected from unprotected dug well they also use the system in tubewell to reduce iron primarily. This system is used to reduce the turbidity as well as iron. Cloth filtration is the simple process of using cloth to block the flow of suspended particles in a water supply. The porous nature of the cloth acts as a membrane to let the water flow through while trapping the larger contaminants of the system, such as dirt and sand, and effectively removing them from the water supply. Cloth filters are very simply implemented, as common material such as cotton cloth can be used and the cloth has to be simply stretched in the pathway of the water so that it is forced to flow through.

Procedure

1) Fold an old sari into four or eight layers.
2) Wrap the folded sari over the mouth of a water container/Tubewell
3) Use container and sari system to collect rain water.

Advantages

- The main advantage is that Sari filtration is cheap, and it is extremely effective against disease.

Disadvantages

- Cannot remove chemicals, or small microorganisms.
- As time goes by the sari pore size increase, making them less effective.

2.5.3 Domestic Filter Unit/ Rapid Sand filter/Bio-sand filter

Household water filtration systems are absolute necessities in the study area as harmful materials are present in the water. Domestic filter is a simple device for purifying and disinfecting raw water for drinking purposes. The community people are using the system to primarily remove the iron and arsenic. The filtration process is unstructured but working to meet their need. In Chandigar union of Durgapur most of the household have developed the system by their own to purify water. Rapid sand filters filter at a rate of 1 to 2 gallons per minute per square feet (gpm/ft2) and use physical straining to trap solids in the pores between sand particles throughout the bed.

2.5.4 Kolshi filtration systems

Three Kolshi filtration systems are used by some households of in Madhupur Upazils of Tangail. The system is more structured and first developed in 1999 in Kushtia, Bangladesh. Later it was upgraded by Prof. Hussam and Dr. Munir in 2001 using composite iron matrix (CIM) as the active arsenic removal component. It retains all the excellent features of a 3-Kolshi system with stability and long life use. 3 Kolshi filtration systems are made up of three pots assembled in such a way as to allow for an integrated triple filtration of water. In this system the top pot is contains coarse sand, for initial filtration of large particulate matter. Between the top pot and the middle pot there is a cloth filter for microbial filtration. The Middle pot contains wood charcoal and fine sand for more microbial filtration. The bottom pot is used to collect the clean water. Water is poured into the unit at the top most pot, and is allowed to filter down through the

system. By the time the water reaches the bottom pot sediment, microbes, and other contaminants removes from it, and remain trapped in the various filters. The advantages and disadvantages of the system are described in the table (Table: 2) above.

2.6 Analysis for the appropriate water purification system in the study area

Area wise uniform water purification technology is more difficult to found but all the systems found in the area is more or less familiar to the community. As they have the tolerance to use the system it is required to identify area wise water purification technology. The options can be justified from the tables below:

Table4: Cost estimate of each system

System	Capacity of storing water	Cost (In BDT)
Slow Bio sand filter (house hold level)	15-20 liter	3000-4000
3 kolshi/ Sono filter	20-25 liter	2000-3000
Pond sand filtration	500-1000 liter	8000-10000
Cloth filtration system	Not applicable	50-100

Table 5: Area wise appropriate water purification system

Technology	Technically sound	Socially acceptable	Low cost	Physiography and climatic condition	Environmental problems	Appropriate for Study area
Bio sand filter	✓	✓	✓	Plain land availability of pond, river water all over the year.	Scarcity of water during dry season	**Mymensingh**
Pond sand filtration	✓	✓	✗			
3 kolshi/ Sono filter	✓	✓	✗	Hilly area, availability of pond and river	Scarcity of water during dry season, iron in water	**Durgapur**
Pond sand filtration	✓	✓	✓			
3 kolshi/ Sono filter	✓	✓	✓	Forest and hilly area	Scarcity of water, iron	**Madhupur**
Bio sand filter	✓	✓	✓			

Source: Field survey, 2011

2.7 Physiographic consideration

The study covers the area of Mymensingh which is plain land and relatively urbanized area. Mighty old Brahmaputra River creates the land arable for the community. So the people in rural part mostly depend on agriculture directly or indirectly. The arable land requires water for irrigation and withdrawal of ground water becomes intense during the dry season. Then the water becomes scarce on the other hand iron in drinking water is found in the study area. Further as the area is a plain land, lot of surface water source is available like pond, lake. Considering the problems and physiography the bio-sand filtration is appropriate for the area.

On the other hand the study area Durgapur covers the remote part of Bangladesh and relatively hilly area. And it is noteworthy to mention that this area is mostly affected by water related problem. Households' area forced to use pond and lake water as the water become rare to found in normal 100 feet deep tubewell during dry season. It is earlier mentioned that the geological structure and physiographic location is the main cause of water unavailability in the area. Further Arsenic and iron in drinking water is found in the area due to the cause of physiographic location and condition. Considering the above situation we can look toward the "3 kolshi or Sono Filter" in the study area. But the "the "Bio-Sand" filtration system is also appropriate for the area.

Except the Madhupur Sadar, other part of the study area is remote and forested. The area also covers hill is significant portion. As the Modhupur forest is located around the study area many people do not have their own land. So any permanent structure is not possible. As iron is found in some part of the study area and many people lacks tubewell the 3 kolshi or "Bio-Sand" filtration system can work for the community as this system do not requires any permanent structure.

2.8 Design required

Form the above matrix (Table 4) we can find the design required in the study area. Priority goes on to two systems that are "Pond Sand Filtering" and "Bio Sand Filtering" for the community of Mymensingh and Durgapur. Both the system uses the process of bio-Sand filtration system. As the material required for the system found locally then it will be easy to prepare the system. On the other hand the "Sono Filter" is much more structured we can apply the same design in Madhupur as well. The new design with some modification can solve the barriers and limitation identified in this study.

2.9 Assessing new design

During the field visit, different unstructured technologies are found in different parts of the study area. The community is using indigenous and local materials for water purification. The financial, structural and technological help can make the system more effective and sustainable.

2.9.1 Modified Filth settling/ slow bio sand filter

Community is practicing an unstructured system of water purification (table-3). In most cases the system have some disadvantages they area

- Time consuming and not usable by all aged groups (Child, aged man and women). Because in bio sand filtration system (practiced by the community, table-3)
- Probability to contaminate water during filtration as the process is not structure and properly maintained.

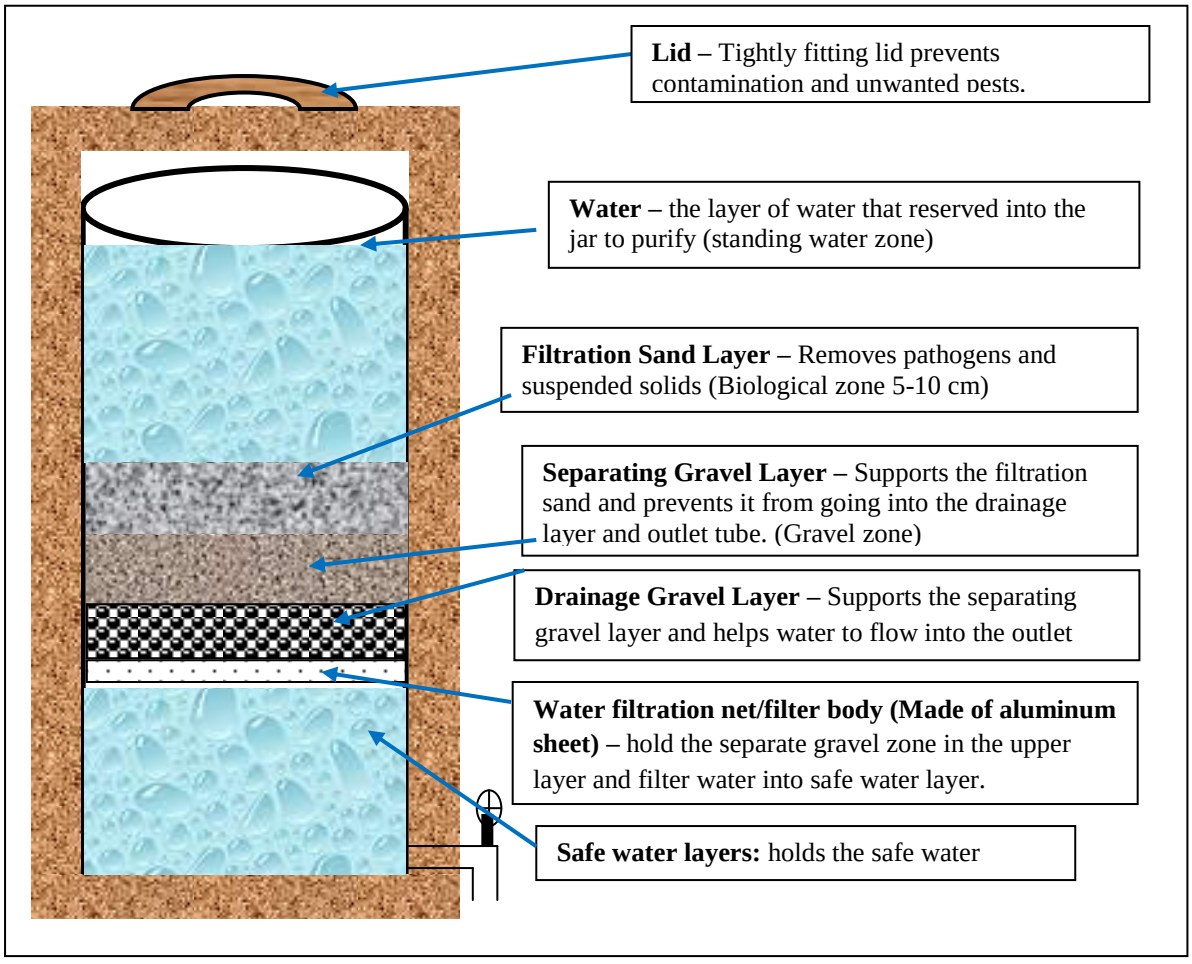


Figure 6: Water purification by sand gravel (Household level), Source: Author, 2011

Above designed water purification system works as contaminated water is poured into the reservoir on an intermittent basis. The water slowly passes through the diffuser and percolates

down through the biological, sand and gravel. Treated water naturally flows from the outlet tube. So the basic modifications area existing systems area

- Not structured to becomes structured

Slow bio sand filtration rapid bio sand filtration system.

2.9.2 Benefit of the bio sand filtration system

- This Filter can be used with any water source such as rainwater, deep groundwater, shallow groundwater, rivers, lakes or other surface water.
- Easy to install.
- Can be use inside of a house of outside of a house.

2.10 Pond sand filtration system

Pond sand filter is a surface water treatment option which is primarily a slow sand filter unit. As people of Durgapur, Madhupur and Mymensingh use the turbid pond water, the pond sand filtration system can work in the area. This system will also work as it is a good option for arsenic mitigation. The pond sand and bio sand filtration system is more or less similar. Using pond sand filtration mechanism in tubewell water will provide the extra facilities like relatively big amount of water can be stored in the water tank that will be beneficiary for household members. They can use it for drinking as well as bathing, cooking, washing and other household purposes.

2.10.1 Design of Pond sand filter

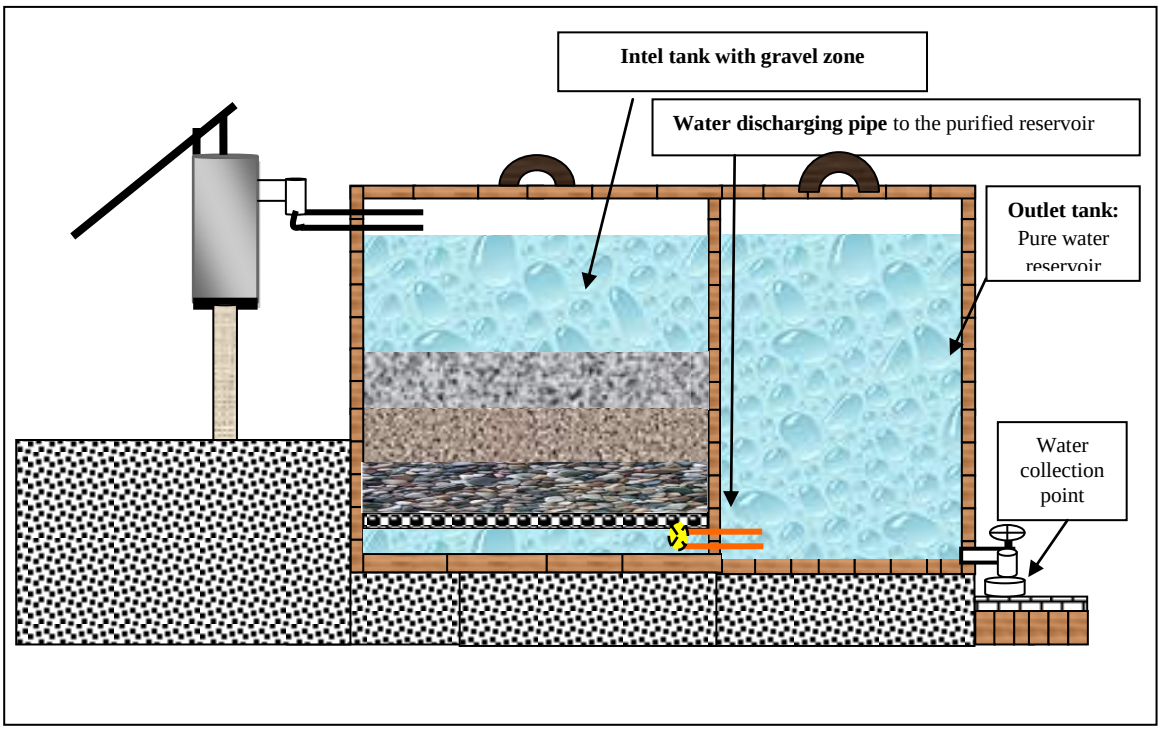


Figure 7: Design of Pond Sand filtration system, Source: Author, 2011

2.10.2 Layer of filtration zone

All the system requires the gravel and sand to filter the system. The pond sand filtration system required the following types of gravel and sand. This sand and gravel is locally available in Mymensingh, Madhupur and Durgapur.

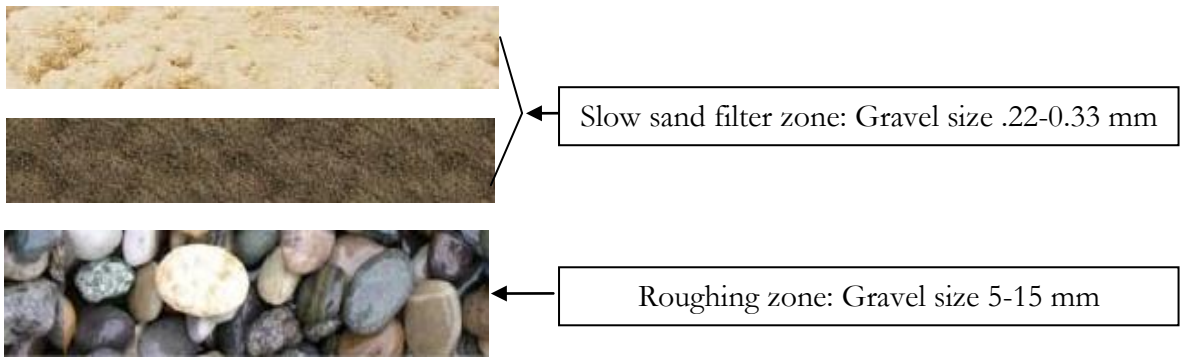


Figure 8: Layer of Filtration Zone

2.10.3 Working process and construction

- The pond sand filter is divided into 2 parts: inlet tank with gravel zone and outlet tank.
- The gravel zone consists of 3 layers loaded by different size of gravel (5-15 mm).
- The Sand Filter bed should be composed of 0.22 mm – 0.35 mm fine sand with a thickness of 60 to 120 cm. There is also a layer of coarse aggregate below the fine sand to support the sand against washing out through under drainage system. The size of the gravel zone is 5-15 mm.

2.10.4 Benefit of the system

- This system can reduce the stretch of water fetching from a long distance.
- This Filter can be used with any water source such as rainwater, deep groundwater, shallow groundwater, rivers, lakes or other surface water.
- By this filtration system sufficient amount of water can be purified that is required for a day (Drinking, Washing, cooking etc.)
- The installation process is easy and uses the locally available materials for water purification.

In order to demonstrate the system in Mymensingh, Madhupur and Durgapur, the change of design and materials, the complexity of water purification system can be removed that is used by the community people. Use of locally available materials can be readily purchased by the community. Then it will be easy to construct the system and make it inexpensively. The

community should not have to make a big investment in implementing and maintaining the system.

The main components of above all system can use brick, wood, PVC pipe, cloth, sand, and gravel, all of which are used by the community. The community has some access to a nearby city in which materials can be purchased and used. Furthermore, many of the construction materials can be easily replaced by local resources. The construction materials of the final design do not have to be the exact materials used in the prototype. With the exception of the sand and gravel, the other materials can be easily replaced by similar materials. For example, wood can be substituted with bamboo or any strong construction materials. The PVC pipe can be replaced by other piping materials.

Chapter III: Conclusion and Recommendation

3.1 Recommendation

In Bangladesh, the groundwater chemistry is not very well known. The development of any filtration system requires a relatively clear understanding of the composition of the water being filtered. To assess the efficiency of the proposed system a big study among the community is required. Community action research can evaluate the process properly. For that purpose some prototype water filtration system should be given to the household (under some controlled samples) so that they can use it. Then the household will be able to evaluate the system properly. According to the action research it will be possible to find most appropriate system for the community. It will also be possible to evaluate a uniform water purification system for all over the area. The field demonstration results will also show the household filtration process if it can effectively remove arsenic and iron as well. The household co-precipitation and filtration process will also find the reliability of the process. It will also find the consumption rate of a household. The result can be useful for analyzing disease reduction of the controlled household. Under this circumstance the recommendation can be categorize as:

1. Community action research is a must in the study area to implement water purification system successfully.
2. The study do not covers all the unions of the study area. Present study covers some specific unions of Mymensingh, Madhupur and Durgapur Upazila so some other unions are un-served. Under this circumstance the massive study requires covering whole upazila.
3. Further Research required so that it can identify the efficiency of proposed system and can calculate the efficiency of the system to reduce disease as well as behavioral change of the community.

3.2 Conclusion

The water filtration system presented here is promising because it is based on uses and locally available materials and without adding any chemicals. A possible scale up of the system to a community based rural and urban pure drinking water supply can be developed under this system. We believe the 3-Kolshi, pond sand and Bio-Sand filtration system can be very effective for filtration of toxic groundwater in Bangladesh and in many parts of the world where locally available pitchers are used for preserving drinking water.

References

Baumgartner, J. (2006). The Effect of User Behavior on the Performance of Two Household Water Filtration Systems. Masters of Science thesis. Department of Population and International Health, Harvard School of Public Health. Boston, Massachusetts, USA.

Collins, M. R. (1998). Assessing Slow Sand Filtration and Proven Modifications. In Small Systems Water Treatment Technologies: State of the Art Workshop. NEWWA Joint Regional Operations Conference and Exhibition. Marlborough, Massachusetts.

Duke, W. and D. Baker. (2005). The Use and Performance of the Biosand Filter in the Artibonite Valley of Haiti: A Field Study of 107 Households, University of Victoria, Canada.

Earwaker, P. (2006). Evaluation of Household BioSand Filters in Ethiopia. Master of Science thesis in Water Management (Community Water Supply). Institute of Water and Environment, Cranfield University, Silsoe, United Kingdom.

McNeill, L. S. and Edwards, M. (1995).Soluble Arsenic Removal at Water Treatment Plants. Jour. AWWA 87(4), 105-113.

Ngai, T., Shrestha, R., Dangol, B., Maharjan, M., & S. Murcott. (2007). Design for Sustainable development – Household drinking water filter for arsenic and pathogen treatment in Nepal. Journal of Environmental Science and Health Part A. 42, 1879-1888.

Sobsey, Mark D. (2006). Comparative Analysis of Three Sustainable Point of Use Drinking Water Treatment Technologies for Developing Nations.

Sobsey, M.D. (2007). Biosand filter reduces diarrheal disease in Dominican Republic villages. UNC Press Release.

Stauber, C.E.,Elliott, M.A., Koksal, F., Ortiz, G.M., DiGiano, F.A., and M.D. Sobsey. (2006).Characterization of the biosand filter for E. Coli reductions from household drinking water under controlled laboratory and field use conditions. Water Science & Technology. 54:3; 1–7. IWA Publishing.

Meng, X. G., Bang, S. B. and Korfiatis, G. P. (2000). Effects of Silicate, Sulfate, and Carbonate on Arsenic Removal by Ferric Chloride, Water Research, 34,1255-1261.

WaterAID-Bangladesh. (2006). Step by Step Implementation Guidelines for RWHSs, House 97/B, Road 25, Banani Dhaka, 1213 , Bangladesh (http:www.//wateraid.org last accessed 10.01.2011)

UN-HABITAT. (2005).Rainwater Harvesting and Utilisation Rainwater Harvesting and Utilisation, Book 3: Project Managers & Implementing Agencies (http://www.unhabitat.org/last accessed 02.02.2011)

Summary of Problem and need of verification (Tool pack for FGD)

Problems	Probability of Correlation with (Questions)	Verification need
Diarrhoea	• Water (Surface sources) • Contamination of ground water source may cause disease • Latrine condition and defecation practice • Hygiene practice • Seasonality of diseases • How long a person have to spend for illness	Analysis of Water Quality Parameters both Surface and Ground water (Physical, Chemical, Biological)
Skin diseases	• Water (Surface sources) • Latrine condition • defecation practice • Hygiene practice • Seasonality of diseases • How long a person have to spend for illness	Analysis of Water Quality, hygiene practice, defecation practice, latrine condition is needed.
Many household don't have own tube well and latrine and don't have access to safe water and latrine.	• From where they collect water. • Where the members of household defecate	From where they collect safe water or are this types of people use unsafe water and latrine.
Distance of water source	• Causes that make them use other source of water (Pond, lake, canal, river) • Time of water collection • Amount of water have to carry in each day • Does it impact on the health of the women or female members? • Is there any sexual harassment during water hauling	Physical verification and FGD is will bring the answer.
Use of unsafe water and unsafe water carrying elements (e.g. pots, jars, buckets).	• What types of jars, buckets, pots, and containers are used for water carrying? • Regularity of cleanliness. • Distance of tube well related to latrine and other susceptible sources of water like (Congested pond, canal)	Do the household use unsafe and unclean water hauling containers?
Seasonality of water	• Water Dry season. • During flood or rainy season. • Which source use?	Find the Seasonality of water, what source of water use in dry season.
Lack of Water, Sanitation and hygiene knowledge	• Types of latrine used by the family member. • Physical fitness of latrine.	Disease may cause form the damaged latrine. So verification is need to identify is people using the

	• Children defecation Practice • When child gets diarrhoea care givers only give ORS. Why don't they go for health service?	damaged latrine?
Lacking of Hand washing behavior	• hand washing behavior (After child defecation, before eating, before preparing food,) • what types of washing materials used (Soap, ash)	Need to verify the hand washing behavior.
Latrine condition and cleanliness	• Damaged or unsafe latrine may pollute the environment and people may affect. • Diarrhoea and skin disease may cause due to use of unclean latrine.	Area wise physical verification and analysis is needed. Need to understand the sharing facilities. Diarrhoea and other diseases may found in these particular households.
Gender discrimination	• In the case of water carrying and latrine cleaning about 80% female member of household is responsible where male has negligible participation. • Does it hamper the education of child especially female children.	Need to identify the causes.
Problem of waste management	• Household waste pollutes the environment and cause diseases.	Physical verification to identify the intensity of problem.
Lack of knowledge about water harvesting system	• Is the community familiar with any water harvesting system or process (if yes what types). • If no then why • What source and system of water is safe and affordable for them.	

Water, Sanitation and Hygiene promotion in Banglades

Habitat for Humanity International-Bangladesh

Dhaka HRC (North)

Basic question for FGD

FGD with	Community people		Male	Female	Date:	
	Leader		Male	Female	Time:	
	Adolescent girls		Female		Place:	
	PNGO, Govt. representatives		Mix (Male& Female)			
Main objectives	**Objectives of the FGD**	**Information we have already got**	**Causes**	**Does it have any negative effect on health or other sectors**	**What initiatives household take as alternatives to cope with the situation**	**According to them what is the best solution of the problem**
Main objectives of the FGD	What types of problems related to water prevails in the area					

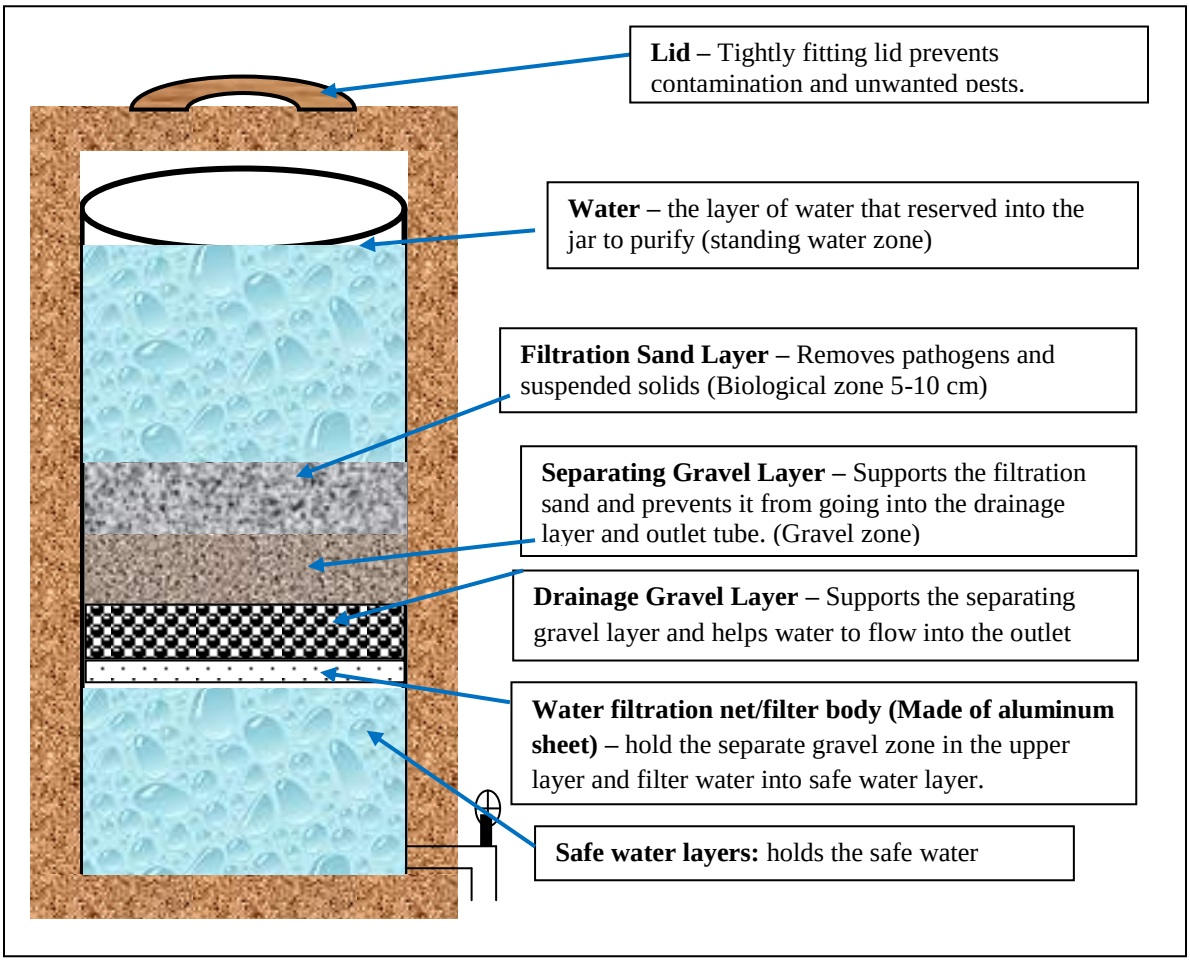
Main objectives	**Objectives of the FGD**	**Information we have already got**	**Causes**	**Does it have any negative effect on health or other sectors**	**What initiatives household take as alternatives to cope with the situation**	**According to them what is the best solution of the problem**
Main objectives of the FGD	Find out the causes of Water born diseases (Diarrhoea, Skin diseases etc)	Diarrhoea and Skin Disease prevails in the study area				
		Lack of Water, Sanitation and hygiene knowledge				
		Some house hold use pond, lake and sometimes household have to travel more than 150 feet				

Main objectives	**Objectives of the FGD**	**Information we have already got**	**Causes**	**Does it have any negative effect on health or other sectors**	**What initiatives household take as alternatives to cope with the situation**	**According to them what is the best solution of the problem**
Main objectives of the FGD	Find out appropriate water harvesting system	<u>Seasonality of water.</u> Ask the question to find out is there any scarcity of water (Summer, winter) if yes then learn details				
		About 95% people use tube well water and no other water sources				

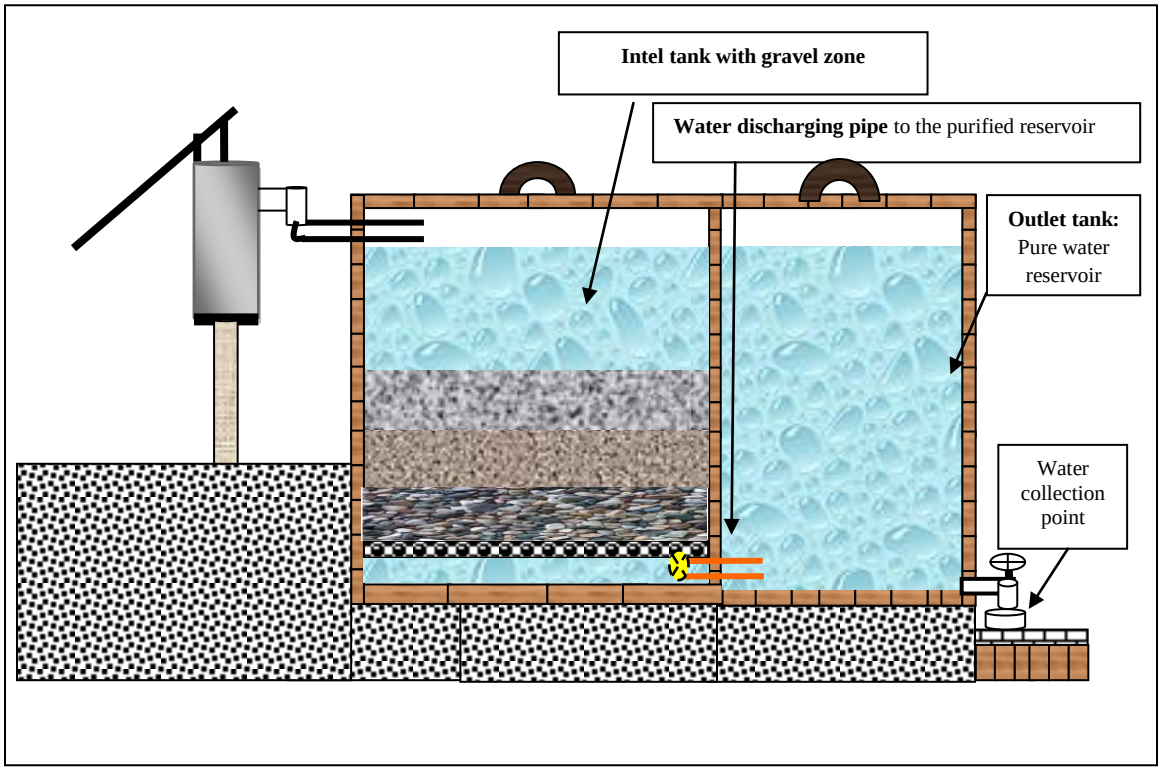
Main objectives	**Objectives of the FGD**	**Information we have already got**	**Causes**	**Does it have any negative effect on health or other sectors**	**What initiatives household take as alternatives to cope with the situation**	**According to them what is the best solution of the problem**
Main objectives of the FGD	Find out appropriate water purification system	No water purification system				
Cross cutting issues and objectives	Gender issues	81% female members are involve for house hold water carrying and for cleaning latrine				
	Latrine cleanliness	43% in Mymensingh and 32% in Durgapur clean their latrine once in a week and 21% in Mymensingh, 14% in Madhupur and 11% in Durgapur clean their latrine in a month				

Main objectives	**Objectives of the FGD**	**Information we have already got**	**Causes**	**Does it have any negative effect on health or other sectors**	**What initiatives household take as alternatives to cope with the situation**	**According to them what is the best solution of the problem**
Cross cutting issues and objectives	Health service	Only 5.11% house hold go for health services				
	Latrine conditions	In Madhupur and Durgapur 41.83% household use off set (Joint water seal) and 24.97% use off set (without water seal) latrine. Many people use pit and hanging latrine.				
		In Mymensingh 2.60%, in Madhupur 4.18% and in Durgapur 3.65% household don't have latrine				

Design for slow sand filter (household level)
Modification of Filth settling/ slow sand filter/Bio-Sand filter found in Mymensingh



Design of Pond sand filter (Household level)
Modification of Sand filter Found in Durgapur



Budget for pond sand filter

Item No.	Description of the material	Quantity	Rate (Tk.)	Amount (Tk.)
1.	**Cement:** Normal cement, 50 kg per bag, initial setting time 40-50 minutes and final setting time 8-12 hours	5 bags	400/bag	2000.00
2.	**Sand:** Good quality local coarse sand. Free from clay, silt, organic matter and shells.	45cft	15/cft	675.00
4.	**Gravel:** Good quality	10 kg		200
5.	**Brick:** First class Brick free from any defects.	650 nos.	9/no.	5850.00
6.	**Khoa:** Broken Brick of 1st class or picked, size from ¾ inch to ¼ inch of angular shape	5 cft	50/cft	250.00
7.	**PVC pipe with elbow**	As required	200	200.00
8.	**Tap with GI Pipe**	3 feet		250.00
9.	**Aluminum sheet**	As required	200	200
9	**Ms rod**	10 kg	60	400
10	**Labor**	2 (3days)	600	1800
	Total cost			11825

Required materials

- Brick
- Sand, silt, gravel.
- Tap with GI pipe
- PVC pipe to connect tubewell with the water tank
- MS rod

Required condition

Length of the reservoir= 3feet
Width of the reservoir= 3feet
Height of the reservoir= 3 feet

Intel tank

Length of the reservoir = 3 feet
Width of the reservoir = 3 feet
Height of the tank = 2.5 feet