Water Supply and Sanitation in Peri-urban Areas in Developing Country: 
A Case Study of Faisalabad, Punjab, Pakistan

SHAHBAZ ALI KHAN

SEMINAR VERSION

Master’s programme
Science for Sustainable Development

Master’s Thesis, 30 ECTS credits

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Abstract:

The purpose of this paper is to assess prevailed water and sanitation issues in peri-urban areas of Punjab, Pakistan. The suitable ways to develop sustainable sanitation system in relation with governance support need to be found for such zones. The analysis of empirical research suggested few important results as follow: global water and sanitation issues in peri-urban zones correlated with area specific issues; public awareness and guidelines for operation of technical systems suggested as solution in designed model was a major challenge. Inhabitants were aware of re-use of human wastes in agriculture because of old tradition in Pakistan. The usage and handling of dry toilet system was also another challenge. Corruption in society at each level from local area to government found to be the major hurdle for successful implementation of any project.

Key words: environment, peri-urban areas, sludge ponds, wastewater, water supply and sanitation
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABR:</td>
<td>Anaerobic Baffled Reactor</td>
</tr>
<tr>
<td>ASB:</td>
<td>Anjuman Samaji Bahbood</td>
</tr>
<tr>
<td>CPP:</td>
<td>Changa Pani Program</td>
</tr>
<tr>
<td>DUDT:</td>
<td>Dry Urine Diverting Toilet</td>
</tr>
<tr>
<td>FDA:</td>
<td>Faisalabad Development Authority</td>
</tr>
<tr>
<td>FOG:</td>
<td>Fat Oil and Grease</td>
</tr>
<tr>
<td>IBNET:</td>
<td>International Benchmarking Network for Water and Sanitation Utilities</td>
</tr>
<tr>
<td>MDG:</td>
<td>Millennium Development Goals</td>
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<tr>
<td>Mgd:</td>
<td>Million Gallons per Day</td>
</tr>
<tr>
<td>NOC:</td>
<td>No Objection Certificate</td>
</tr>
<tr>
<td>OPP:</td>
<td>Orangi Pilot Project</td>
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<tr>
<td>PDHS:</td>
<td>Pakistan Demographic Health Survey</td>
</tr>
<tr>
<td>PPAF:</td>
<td>Pakistan Poverty Alleviation Fund</td>
</tr>
<tr>
<td>TMA:</td>
<td>Tehsil Municipal Administration</td>
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<tr>
<td>UC:</td>
<td>Union Council</td>
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<tr>
<td>WAPDA:</td>
<td>Water and Power Development Authority</td>
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<tr>
<td>WASA:</td>
<td>Water and Sanitation Agency</td>
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<tr>
<td>WSS:</td>
<td>Water Supply and Sanitation</td>
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(Some definitions of local language words)

- Lal Pumps: Red colored motor pumps which are mostly used in households of Punjab
- Gutter: Septic tank which collects all wastewater from household usually place outside the house
- Tanki: A big closed container for storage of water.
- Kushali: It means prosperity.
1. Introduction:

Peri-urban area is a transition zone which has both rural and urban placements together. It is a large landscape area consisting of farms, villages, small forests and places for quarries. In a peri-urban area the geographical space changes because of increasing anthropogenic activities. Overall, peri-urban environment is in a dynamic flux due to rapid changes in contributing factors such as socioeconomic, environment, ecology, and hydrology. These zones are neither urban nor rural. These areas can be easily overlooked by the administration (McGregor et al., 2006). They are usually bereft of municipal services because of illegal land structure which Governments are unable to recognize or legitimize. People violate tenure laws for land development without having legal land tenure (Hogrewe et al., 1993). Therefore, area remains legally non-urbanized. Water and sanitation are the most important aspects to handle for achieving sustainable society. Globally, water resource competition in society causes water scarcity especially level of aquifer is rapidly deploying. It could affect 1.2 billion urban populations in future. Sanitation is directly associated with water, limited water resource causes bad sanitation which leads to vulnerable environment and health risks in society (Marshall et al., 2009).

People from diverse economic statuses live in these areas and the standard of Water Supply and Sanitation (WSS) services is heterogeneous all over. The economic status of individuals determines access to better quality of WSS services within their households. It confirms unequal distribution of WSS services standards as (Marshall et al., 2009) underscores; marginalized people have unequal access to basic water resource to meet livelihood requirements.

1.1 WSS Situation in Pakistan:

Pakistan is located in South Asia, it covers area around 880,000 km² including all provinces such as Punjab, Sindh, Baluchistan, Khyber Pakhtunkhwa (Asian Development Bank, 2008). Total population is 160.9 million as estimated, it is growing at a rate of 1.8% per year. Pakistan is second most populous country in South Asia (Pakistan country paper: SACOSAN III, 2008).
Each province has varying social, geographical and climatic conditions. Therefore, the environmental impacts and components of WSS system in peri-urban settlements vary slightly in all provinces. Surface and groundwater are basic sources for water supply to households. Majority areas are not connected with municipal WSS services. Hand or motor pumps are sources of supply and pumps or private wells are in vicinity of households. The shallow bore holes are common issue in all regions because of absence of a municipal supportive option. In some provinces, water reservoirs from small lakes, rivers and canals in vicinity of areas are other sources of supply. Absence of water quality tests before distribution leads to health risks. Pit latrines at households, exclusive huts for females and open fields are used in areas around under developed cities. The ordinary pour flush toilet is used in areas around more developed cities (WWF, n. d.). Wastewater from households is washed with rain water either through open drains to agriculture farms or end up in near vacant places. In a hilly terrain, wastewater flows down to valley via open stream. Overall environmental health impacts are similar and common because of inadequacy and inefficiency of wastewater disposal system in such areas of Pakistan.

1.2 WSS Situation in Punjab:

Punjab is the second largest province in Pakistan having large area approximately 205,345 km²; it has huge population around 79,429,701 inhabitants (World Lingo, 2003). WSS situation in Punjab is similar to other provinces of the country in general terms. The difference is that since Punjab province is more developed therefore WSS situation in peri-urban setups around major cities is bit better than rest of the country. Groundwater through hand or motor pumps and private wells is the major source of water supply in the province. Some other unreliable sources
such as river and canal are also used. It is causing rapid depletion of aquifer because of no efficient recharge plan and proper governance. The quality of aquifer is bad in many parts of Punjab which causes health risks in dwellers. The access of toilet facility varies if in some areas no toilet facility exists at home then people are accustomed to go to the open fields for defecation. In some areas, pan toilet and ordinary pour flush toilet at home are connected with open sewerage in streets. The open sewerage receives other wastewater from households as well. Open drains overflow and wastewater ponds form in low lying areas. This wastewater is used for irrigation and discharged to fresh water bodies via drain network which flows into rivers. That contaminated water from river or water bodies is again used for irrigation, drinking, and domestic purposes. This situation causes environmental impacts on ecosystem and human health (Punjab urban water and sanitation policy, 2007).

1.3 WSS Situation in Faisalabad:

Faisalabad city is located on rolling flat surface of northeast part of Punjab with total area around 830 km$^2$. According to censuses 2009, Total population has reached at 2,793,721 inhabitants (Administrator, 2010). Overall WSS conditions are similar to other parts of the country. Statistical findings (Pre-empting poverty and promoting prosperity: strategic development plan, 2006) furnish that 60 percent of population has no access to piped water. 35 percent have inadequate sewerage system. There is a grave water and sanitation problem in the area and it entails that proper attention be given to the sanitation needs and planning of the drainage system in Faisalabad. The bad services keep population predisposed to illness or disease. The cost of the disease caused by the non-availability of efficient water and sanitation services is high for the people regarding treatment of disease and lost wages. The groundwater is brackish in those areas of Faisalabad district which locate far from Ravi River. Total 820 rural areas (including slums or peri-urban) exist in Faisalabad city district area; 700 of them lie in brackish groundwater zone. In those areas, the source of sweet water is small canals passing through the area or seepage water from unlined canals. A large number of households have no water supply connections; they get water through electric motor pump called “Lal Pumps” and hand pumps. The wastewater drainage system in Faisalabad district serves a large community area by open drains wherein wastewater disposes directly. Black-water from ordinary pour flush toilet with other wastewater collects in septic tanks (gutter) outside household; that effluent discharges to open drains (Pre-empting poverty and promoting prosperity: strategic development plan, 2006).

1.4 Overall Water and Sanitation Issues:

General issues of WSS in peri-areas of the country are similar and as follow: socio-economic and physical conditions prevailing in a particular region, defines the convenience to obtain water from ground and surface sources. Geographical location matters as people either have access to groundwater at their homes or they need to go to private well/hand pumps installed at some distance from the home. They want to fulfill their domestic and sanitation needs regardless of water quality. In both ways, it leads to an extra-ordinary stress on the aquifer, because there is no concept of recharge which results in shallow boreholes. Unlimited number of wells and pumps are installed without measuring the quantity of water because lack of effective mitigation measure. WWF (2007) confirms that new wells are installed without any logical plan that leads to unequal level of extract and recharge of groundwater.
Another major issue is that people are directly exposed to health risks caused by untreated effluent and contamination of groundwater. Unavailability of wastewater disposal systems is the reason for this major issue in peri-urban areas (Marshall et al., 2009). The grey-water and black-water from household and rainwater from roofs collectively flow out of houses in open streams and ends up in sludge ponds in the streets. Environmental health hazards in an improper water disposal mechanism and stagnant wastewater in streams and ponds (Hogrewe et al., 1993). These are hubs for pathogenic micro-organisms found in human excreta. Drangert (2010c) points out that adult defecate in designated places and their feces are covered; it is not considered as open defecation. But when defecation places via pour-flush toilets or pit latrines are connected with the sewerage drains which pass through open streams in street; urine and feces are exposed which can be considered as open defecation. The children are not aware of bad impacts so they are used to defecate in public places. Wastewater conveyance from houses to collection system is usually inadequate and inefficient. The narrow, poorly designed and structured WSS systems become overflowed and resultantly cause health and environmental risks especially to children because they are used to play in that degraded environment all the day. Chemical contents penetrate from external sources affects the quality of aquifer. Water quality degrades leading to numerous stomach and other water-borne diseases. Drangert (2010b) stresses that the groundwater becomes contaminated in peri-urban area where infiltration from outlets of wastewater can transport pathogens to groundwater. The pathogenic contents reach groundwater and some parts of chemical organisms dissolve in soil depending on pH and temperature of water or distance to the aquifer.

Untreated sludge from such areas is either applied to agricultural fields in the vicinity or piled in the form of heaps. Inhabitants are exposed to these untreated wastes and so are the farmers in the fields as Buechler et al. (2006) emphasize. It causes health impacts such as Helminthes infections in farmers and people living near farms. The limited water resources cause usage of that sludge for irrigation and aquaculture in peri-urban setup. It is considered to be easy and cheap because the cost of extracting groundwater is higher with the prevailing shortage of electricity. The contents such as nitrogen and phosphorus can much contribute to increase agriculture production for those communities but degraded environment results in vulnerability to farmer health (Parkinson et al., 2003).

Availability of safe WSS services is the right of every individual in an area; it should be provided properly and without failure, either by private or public sources. A reasonable strategy for aquifer to achieve balance of extraction and recharge should be implemented. A proper infrastructure capable of disposing wastewater from households to towns without exposing it to environment and aquifer may be a mitigation measure. A sound WSS system can also reduce health impacts for the inhabitants and the farmers. Many alternative technical systems are available in developing world which is sustainable based on factors such as economy, environment and society as compared to the existing conventional WSS pipelines systems. Therefore, some of them are selected to develop efficient WSS system. They would require limited energy, manpower and cost for successfully operation in existing circumstances. Another reason is this that similar kind of products is available in society. The standard of WSS services should be the same for each inhabitant in a town regardless of economic status. Political groups and Government understand the importance of WSS problems in these areas and often conduct surveys for projects but most of the projects remain unable to reach the phase of successful implementation. This situation entails that we assess the hindrance-factors which come in the way of the successful implementation of these projects.
1.5 Objective and Research Questions:

The objective is to explore existing water and sanitation situation in a peri-urban area of Punjab with relation to those issues identified above. The potential success of designed technical solutions in structured model is assessed.

Rafique colony under Union Council (UC) -272 is peri-urban area in Faisalabad where empirical research is conducted.

Some specified research questions are defined to meet objective as follow:

• What is the current situation of water and sanitation in peri-urban area of Punjab?
• What possible alternative can be adopted to stop depending on the groundwater resource?
• How the infrastructure of sustainable WSS within area should develop to protect the health and environment?
• What are the obstacles for Government to implement any project which is under consideration?
2. Background

In Pakistan, WSS system is unsustainable which causes higher rate of diseases so the mortality and morbidity rates are critical threat to society (National drinking water policy, 2009). Pakistan Demographic Health Survey (PDHS) 2006-7 shows: Access to improved water: 36% population have piped water in their homes and 49% gets water from tube wells. Situation of sanitation: 52% people have access to independent improved toilet which is piped or poured flush to sewer or septic and 28% has no facility of toilets (Rahaim, 2010).

In Punjab, 55% population has access to piped water. Many cities have higher percentage of sewers connections than piped water. Water and Sanitation Agency (WASA) and Tehsil Municipal Administration (TMA) collect wastewater in major cities of Punjab. Multiple types of wastewater collection and drain system exist. In almost every city, the capacity of managing the services for handling wastewater is low as compared to the quantity of wastewater generated every day (Punjab urban water and sanitation policy, 2007).

In Faisalabad city, WASA provides 193,000 sewer connections from south to east including households having no services. Those households get water from shallow tube well instead of piped infrastructure. Such a large number of connections show highest coverage. The water production capacity is 65 million gallon per day (mgd) which extracts from well situated in the Chenab River and supplies to the city. Total time for water supply is around 6 hours per day and the production is below the stated requirement (i.e. 165 mgd) by 40 %. The quality of water service is poor in the region and connections are sufficient to supply water for fewer than 50% population. Textile industries produce chemical effluent which is toxic and has high biochemical oxygen demand; all industries except a few throw their effluent in public drains without treatment (Pre-empting poverty and promoting prosperity: strategic development plan, 2006).

Some examples of WSS projects which have been done for peri-urban areas of Pakistan are presented in following section. These examples will be related with context of this paper in discussion section.

2.1 Orangi Pilot Project (OPP):

Orangi is a peri-urban area in Karachi which consists of broad area and large population. It is considered being the largest peri-urban settlement in Asia. WSS situation within this area before 1980 was vulnerable. All water supply methods such as motor pumps, hand pumps, and private wells utilized because of largest settlement. The bucket latrines or soak-pits were the methods used to dispose urine and feces into open sewers. Diseases were widespread because of degraded environment. Health of the people living in the area was at high risk because non-availability of sanitary latrines and covered sewer lines (Shahzad, 2006). The diseases such as typhoid, malaria, diarrhea and scabies were common. Weak drain system caused water logging and reduced property values (Pakistan: Orangi pilot project, 2006). A low cost sanitation model was developed and community was adaptable with it in short time and the environment improved altogether. A component sharing model suggested building sanitation infrastructure from household to lane level. Households were responsible to construct their internal WSS system by their own means. Government was responsible to construct and maintain secondary infrastructure such as main disposal drain and treatment plants which was known to be external development. Orangi Pilot Project (OPP) has beneficially served 865,000 peoples of 108,000
households situated in 7600 lanes of Orangi. During 1982 to 1991, OPP has reduced the mortality rate from 128 per thousand live births to 37 per thousand (Pervaiz et al., 2008).

### 2.2 Changa Pani Program (CPP):

Bader colony under UC-60 in Lahore is another peri-urban example in Punjab where municipal WSS services were absent. The shortage and misuse of groundwater resources (via small motor pumps) were causing critical threat to environment, human health, and food security. The disposal of black-water and grey-water was unsafe in the area; it was performed by excavating small sanitation well because of improper toilets and sewerage system. The wastewater and drinking mixed up most of the time; the health of adults and children affected as a consequence (Hussainy, 2007). The bore wells and shallow hand pumps used for drinking water. Inhabitants were used to complain about the water being salty and stinky. No proper sewerage system was in place; pan toilet and septic tank placed close to hand pumps. The groundwater level of bore wells reached the septic tank level. This contaminated the drinking water and made it stinky. The open drainage was causing vulnerable environment such as bad smell in surrounding area. During rainy seasons, a kind of flood formed in the area which further exacerbated the situation. The water borne-diseases such as diarrhea, jaundice, dysentery and skin diseases were common (Tripathi, 2008). Changa Pani Program (CPP) was developed based on component sharing model similar to OPP. This program provided sustainable WSS system in area and positive consequences, 93% households were satisfied with improved sewerage system and 78% households confirmed about reduction in water borne-diseases (AHK, 2011).

### 2.3 Alternative Technologies for Water and Sanitation:

Some alternative technologies for improving WSS are presented and linked up in a model in this section. They have been used in different developing societies of the world and might be suitable to resolve WSS issues in Punjab Pakistan. The results will be discussed in relation to these technologies in discussion section (Chapter No. 5).

#### 2.3.1 Rainwater Preservation Technique at Household:

Rainwater should be collected and stored safely at individual household level which can increase water supply for domestic use and groundwater recharge. Currently, simple flat roofs with efficient slops are constructed for smooth flow of rainwater. The groundwater is extracted and stored in closed container (Tanki) in society; these containers are commonly available in market.
On left side (Shown in Figure 2.1), a sedimentation container like that closed container used but rather big can be installed within household between surface and ground which can store rainwater properly. The water goes to $8\text{m}^3$ ground storage part of container. When rainy season comes in; a large amount of water is transferred via seepage through to dug-well (from left to right side) with capacity of $10\text{m}^3$ for recharge of groundwater. A bio-sand filter is used on tap with pipe installed on flat roof to treat extracted water of dug-well before transferring extra water to underground water tank again (from right to left). The quality of this water is hygienically good for all purposes including for drinking. The aquifer quality can also be improved by using suggested technique because high levels of nitrate contents which exist in groundwater are reduced by mixing of pure rainwater. The preserved rainwater can contribute approximately 80% of the requirements of household and rest is fulfilled by local aquifer. The stress on aquifer can be reduced by using this system. This example has been experienced in Katmandu, Nepal (Drangert, 2010a). Recommended size of tanks is big but a suitable size of tank can be selected depending on the land size of household. Another issue could be reconstruction within each household for this system. Although, the cost would be higher but proper governance could make it successful.

### 2.3.2 Reverse Osmosis Technique Plant for Colony:

In reverse osmosis process solvents are filtered or removed from water or solution by using membrane filtration. A semi permeable membrane is used which converts concentrated solution into diluted one.
In this way, solvent travels from dilute to concentration side of membrane, the level of concentrations become equal on both sides at the end. The flow of solvent is controlled by using opposing hydrostatic pressure to concentrated solution. The pressure required to complete the process of solvent transfer is known as osmotic pressure. If the hydrostatic pressure is higher than osmotic pressure (Shown in Figure 2.2), solvent will flow in reverse direction from concentrated to diluted solution (http://www.aquatechnology.net/reverse_osmosis.html).

This technique can purify brackish groundwater and further supply to area on equal level, it has been suggested in a municipal (WASA) designed project for Latif garden (peri-urban) in Faisalabad. It was suggested in this project that groundwater should be used only for bathing, laundry, and toilet not for drinking and kitchen purposes. Therefore, groundwater storage tank of 16,500 gallons capacity and overhead tank of 10,000 gallons for supply to whole area could be installed under the control of WASA. A reverse osmosis water treatment plant with capacity of 800 gallons/ hour suggested installing for providing safe water for kitchen and drinking purposes (Digest of Project, 2006). The cost of the system including energy resources and proper governance might be problematic for the success of this option.

2.3.3 Grey-water Treatment Option at Household:

Simple screen and grease traps on drain points of grey-water (i.e. kitchen and bathroom) in household can be installed. Solid waste particles from grey-water can be extracted out instead of flushing down to drain because micro-organisms in solid particles can produce other organic matters if flushed down (Drangert and Tonderski, 2010). Fat Oil and Grease (FOG) content is rinsed by hot water and detergents; they become distinct solid contents with cool water. On left side (Shown in Figure 2.3): simple grease trap is used for a single household; the warm grey-water passes through screen or grease trap but solid particles are trapped. The size of grease trap must be large enough to provide retention time to solidify FOG contents on surface. Two compartments are placed together; screen places on small compartment where grey-water gathers and cools down and overflows to bigger one.
The grease is collected on surface of screen which can be removed; the pipeline carries only effluent with limited solids so grey-water can be easily treated. On right side (Shown in Figure 2.3); a simple plastic colander is used to catch solid particles of wastes through filter (Drangert and Tonderski, 2010). It is simple, economical and user friendly option to implement.

2.3.4 Household Toilet:

The suggested toilet (Shown in Figure 2.4) is designed based on concept of Dry Urine Diverting Toilet (DUDT) but physical structure has kept similar to existing pour flush toilet in Pakistan because of socio-cultural adaptability issue. DUDT type system collects urine and feces separately in containers at individual household. These containers might be installed in external area of the house. This system does not pollute environment or waste water and the hazardous human waste can be treated safely within household by using some chemical material like ammonia or urea to produce potential fertilizer. Drangert (2010d) presents scientific treatment process with certain conditions: the ammonia has a quality of distributing itself in material; it is used for biological life and many nitrogen fertilizers. First, ammonia is applied for feces treatment before using as fertilizer; it gets into NH₃ form which can be found as gas and water solved material. During this treatment process, toxic emissions are produced so such treatment needs to be done in closed place. Such idea is known to be ecological sanitation or eco-san. The recommendation for treatment is as follow: the extra amount of urea around 2% is mixed with material in higher temperature than 20°C for eight weeks of storage time. The urea produces ability in material to hold strong concentration of nitrogen. If the value of urea is doubled; it can increase the speed of inactivation of pathogens and storage time can be reduced to half.

Urine does not need any addition of urea because it contains specific amount of nitrogen approximately 7-8 g/l. The bacteria react naturally and form urea in collection system. Such enzymatic degradation interacts with enzyme urea and converts urea into ammonia and carbonate. In this way, the value of pH is increased from 7 to 9 which also increase the
concentration of uncharged ammonia in collected solution; it acts as sanitizing element. The collection container must be closed and air tight because the pipes are never filled up with liquid. If the container is not closed properly, ammonia can be lost and bad smell prevailed in surrounding environment. The pathogens transmission in urine occurs when urine mixes with fecal matter. If urine is collected separately, the chances of disease transmission can be reduced. The urine should not be diluted for efficient reduction of pathogens; diluted urine cannot work as efficient sanitization agent. The value for uncharged ammonia should be at least 40mm (millimeter) in urine for inactivation of all pathogenic organisms (Drangert, 2010d).

Figure 2.4: Design of toilet system for individual household. Source: Picture of DUDT has been taken from (Deegener et al., 2006)

To perform all these treatments to urine and feces efficiently; sanitation workers of WASA can add suggested chemical substance in feces and urine collection containers after a specified period of time and conditions. The same workers can remove material from the containers. Toilet seat is placed at some height from floor because the water is required to clean body after defecation in
Islamic culture. Separate pipes for water supply and drain of ablution water can be installed on floor of toilet; that ablution water might be treated at municipal level.

2.3.5 Dual Septic Tanks for Colony:

This is anaerobic system and known to be an alternative option for treating grey-water (Shown in Figure 2.5) with two inter-linked water tanks made of plastic or concrete and fixed underground. The grey-water needs to flow with little turbulence because it can disturb movement of solid material. A wide pipeline between two tanks is placed below the water surface which reduces turbulence and stop scum in second drainage tank. The level of groundwater on target place should be considered before installing this system. If septic tank installs properly with sufficient distance from aquifer; there will be no contamination to aquifer and no bad odor. It eliminates FOG and solid particles present on water surface or in bottom. It can remove 30-75 percent of biodegradable substances from grey-water and the remaining part stays in the effluent.

![Dual Septic Tanks Diagram](image)

Figure 2.5: Dual septic tanks installation in streets. Source: Modified Picture from (Drangert and Tonderski, 2010): “Grey-water Treatment, Sustainable Sanitation for the 21st Century”, Chapter No 4.7 (Figure 4.7-6)

Such system is efficient with low flow rate; estimated retention time is 24 hours. Second tank is divided in two portions to flow water up and down an extra time which can improve treatment. This system is unable to remove all substances; some metals, sludge, and effluent remain in septic tank. A person can contribute approximately 70 kg of dewatered sludge annually to wastewater; it is required to remove sludge from tank to work efficiently depending on size of the tank (Drangert & Tonderski, 2010).

2.3.6 Anaerobic Baffled Reactor (ABR) Systems for Colony:

ABR system (Shown in Figure 2.6) has one septic tank with many small baffled compartments. The wastewater fluctuates from bottom to top of surface with baffle forces; no application of energy is required. One ABR system with an operator can facilitate several houses within a town. ABR eliminates organic matters from grey-water efficiently and effectively. A large
amount of solids gathers in sediment of first septic tank and less in following compartments. Inlets are on bottom of each smaller compartment so the flow of wastewater activates fixed sludge. The gas bubbles bring sludge particles up to the top; those particles will fix in sediment because of higher density. The velocity of water flow does not let anaerobic sludge leave reactor with effluent. The particles must be as floating blanket where associated bacteria can easily penetrate to wastewater and degrades organic contents; the sludge should be removed annually. Such treatment system can hold the hydraulic and organic loads; another characteristic is no risk of clogging. The retention time is approximately 48-72 hours and 50-90 percent organic matter is eliminated. Toxic gases such as carbon dioxide, methane, hydrogen, sulphide, and nitrogenous produce and dissipate in air. The treated effluent which comes out from ABR system is not hygienically safe because this system is not designed to purify wastewater from pathogens, chemicals, and metals. Some ions and microorganisms are discarded because of fixed sludge. The operator can be exposed to health risk when he removes sludge from system (Drangert & Tonderski, 2010).

2.3.7 Combining Alternative Technologies in WSS Model:

A general model for better water and sanitation services was developed by combining all technologies presented above. It might reduce existing WSS problems in peri-urban areas. The model in figure 2.7 indicated designed structure of WSS system; the objects placed in the middle were infrastructural units within household and upper/lower objects placed horizontally considered as centralized units for treatment and management by municipal authority. Certain alternative technology was involved in each object.
Figure 2.7: General water supply and sanitation model developed by author.
3. Materials & Methods:

This research was conducted as pilot study involving interviews of relevant people, development of model, and observation. The pilot was used to assess possibility of suggested approach with limited time and limited number of participants.

3.1 Pilot Study:

The purpose of pilot study in social science research is to assess defined research instruments or methods on small scale as trial for conducting actual or large scale project in future. It identifies major faulty aspects where research project could fail due to inappropriate or complex instruments within project. Pilot study is usually based on quantitative and qualitative methods. In first step, pilot involves interviews to extract issues which need to be addressed in questionnaires for large scale survey. This research tool might also have some shortcomings such as wrong predictions and assumptions on the basis of data obtained from pilot (Teijlingen et al., 2001).

3.2 Interview Methodology:

The basic methods for interviews are presented in following section.

3.2.1 Quantitative and Qualitative Research Methods:

Quantitative research is a part of social research which contains empirical methods and statements. Empirical statement can be defined as a descriptive statement which explores “what is” the case in the “real world” rather than what “ought” to be the case” (Sukamolson, n.d). These statements are expressed in numerical terms. Survey research is the most popular type of quantitative research, it is a systematic way of gathering information from respondents to understand or access some important aspects of behaviors of focused population. The questionnaire design, sampling, and questionnaire administration are developed for such kind of research. The in-person interview is the most common type of survey, in which interviewer asks questions from respondents in face to face situation. The structured and un-structured questionnaires are collectively used which provide flexible type of information from survey. Observation is an additional component of survey which also can be used when it is required (Sukamolson, n.d)

Qualitative research can be defined as collection of textual information specifically focused on some defined objectives (Dunne et al., 2005). This collected data is then analyzed to conclude the results based on that specific information. Qualitative research can be done by different means such as interviews, group discussion and participant observation, with specific focus upon learning about facts and viewpoints. The interviews as a research method seem as a method of good importance based on its effectiveness to help the researcher on its way to research. The structured and semi-structured are types of interviews. It is almost a must factor to use some kind of question by the interviewer to get response from the interviewee. Structured interview involves the follow up of pre conceived schedule by the interviewer and must be closely obeyed. It may involve the tightly fixed appointment and well prepared questionnaires. Closed ended questionnaires are mostly used which might help keep the focus of the research as it is fully
scheduled and structured. The semi-structured interviews have some sort of flexibility in the interview process. They include some sort of schedule as well but there is permission to move away from the track. It is obvious every interview is based upon some kind of focus which in turn is based on the objective of research. But semi-structured interviews allow the interviewer to get some valuable information if possible apart from the scheduled and fixed one as he can ask some additional question deducted from the interviewee reply. This kind of interview mostly makes use of open ended questions and the interviewees have the opportunity to express their views freely without any kind of restriction of being on track or focus. But it is the interviewer who has to consider these aspects for having the appropriate data for the research in the designed time period (Mack et al., 2011).

3.2.2 Selection of Interviewee:

To explore WSS situation in Rafique colony and assess improvement of WSS arrangement; total ten random numbers of households were culled out from all streets of area to conduct survey. These selected households (sample) represented the whole colony (population). Nine respondents were males and one was female. To identify hidden realities about disposal of wastewater from household to end point; the interview with sanitation workers in colony was important to get overview of sludge disposal. Therefore, four sanitation workers within Rafique colony were randomly selected to interview.

The main officials of WASA and TMA who control and monitor developmental work under UC-272 could provide information about hurdles to implement WSS project especially in such areas. Unfortunately, TMA officials were not willing to provide information so they forwarded to WASA. Officials within WASA were approached to get information regarding this research. An official has been working as sub engineer at overhead storage (Tanki) located in Gulfshan colony for 3 years; this storage tank supplied water to some connected areas under UC 272. He showed his consent to give the basic information. Then he referred us to his senior for further details on this subject. Senior official has been working as deputy director of planning and development in WASA for 4 years. He agreed to provide all necessary information for this research.

3.2.3 Interview and Survey Questionnaires:

The quantitative type of questionnaires was prepared and complimented with qualitative follow up questions because there was a situation during the survey where I obtained answers for qualitative questions. Generally, the semi-structured and structured interview with open and close-ended questions prepared respectively. They were focused on research themes when gathering data from public, sanitation workers, and Government officials. The local language (Punjabi) was used as medium of communication during public survey and interview of sanitation workers; national language (Urdu) was used to interview WASA officials.

For public survey questionnaires, the multiple choice answers presented in the form of yes/no, like/dislike, agree/disagree for each close-ended question. And general open ended questions used to gather extra information other than focused answer. Several questions were presented under each theme such as “current water and sanitation situation in Rafique colony” and “households’ response on WSS model”. The answers of each quantitative question in each individual survey questionnaire noted and counted which were presented in absolute numbers in results and further used collectively with views obtained from qualitative questions in discussion section. The time consumed at each household was approximately 25 minutes. The
questionnaires for sanitation workers prepared with open ended and closed ended questions under the same theme of “current water and sanitation situation in Rafique colony”. The purpose was to get the hidden realities regarding the final fate of sludge and environmental impacts. Total time consumed with each sanitation worker was around 10 minutes.

For WASA officials, the questionnaires were based on third theme that was “implementation process of projects” by using open ended and close ended questions. Some basic information associated with other themes was obtained from WASA official as well. The communication with first official lasted for about 20 minutes. The office of senior official has been visited two times and he gave 30 minutes for each visit.

3.3 Model Development:

The general kind of model was developed to provide safe drinking water and sanitation facilities to a peri-urban area as the WSS conditions in those areas were causing critical threat to human life. It could provide better services to each inhabitant of area on equal level. Some important alternative technologies for safe WSS were selected from literature which could be feasible to implement in such areas. These technologies had already been used in other developing countries. The results obtained from empirical research were used to assess possibility to use these suggested options including model in existing system.

3.4 Observation:

The general observation of visible degraded environmental objects such as sludge ponds, broken septic tanks outside the houses, closed container (Tanki) and some others in streets within the area was made during survey and some photos were taken. The observation of inner household structures was limited while conducting the survey owing to the socio-cultural restraints which prevail in that community. Personal assessment about WSS system in household was used to arrange some relevant pictures.

3.5 Limitations:

This study contains some limitations. Limited number of respondents around ten was involved which might not provide correct assessment of WSS in the area with large number of households. It would have been more helpful if more respondents had been involved. Females were hesitant to communicate with strangers males in that focused study area because of many social believes and fears. It was the same reason that the observation of WSS system within household was limited. Therefore, majority of interviewees were males approximately nine and only one female. It might be the reason to restrict some important aspects in study which only female could provide because of their involvement in household system for the whole day. Generally, the study provided information about social and technical aspects but not other aspects such as economic. Respondents were unable to understand technical details of suggested technologies especially black-water arrangement; it might be because of their limited knowledge/ awareness or improper explanations. Government officials of water and sanitation organization were not co-operative to provide relevant information for this research. Therefore, only two officials co-operated to provide information.
4. Results:

This chapter contains general description of study area before presentation of results obtained based on research themes.

4.1 Description of Study Area:

Rafique Colony is peri-urban area under UC-272 which is located on north western side of Faisalabad city under the jurisdictions of Jinnah town. It covers a total area of 27 acres. The population and houses in area are 1650 and 215 respectively (Khan, 2006). It has been developing for forty years revealed by household interviewees. Small colonies exist under this UC but this colony has the worst environmental situation among all as observed.

Water supply situation in Rafique colony is vulnerable; initial observation of survey and Khan (2006) reveal that the municipal services of WASA do not exist at all. Inhabitants have to manage all their WSS services by their own means. Electric motor pumps and hand pumps are installed in households to extract groundwater for domestic usage. That water is stored in closed containers made of plastic which are usually placed over roof of houses. Some households also use external source of water supply. Water-borne diseases are prevalent in the area. Grey-water including solid particles, black-water including urine or feces, and rainwater from roof are collectively disposed of from household. The wastewater disposal infrastructure in area does not exist at all. The wastewater flows out from each house and ends up in closest sludge pond via open stream or drain. Two or three ponds serve to gather all wastewater from each household.

Figure 4.1: Picture of UC-272 in Faisalabad Taken from Google Earth
in a street. Solid wastes from household are also thrown in open drain and pond (Figure 4.2). The chemical contents from stagnant wastewater in pond penetrate to aquifer easily which reduces quality of groundwater. The inhabitants of the area become diseased on consumption of this drink. Many other diseases are environmentally transmitted by exposed excreta/urine in wastewater.
The streets which are near to agriculture farms are prone to collection of wastewater in a vacant plot. From there wastewater is supplied to farms (Figure 4.3). Human and animal are also used to defecate in fields; they have organisms in their bodies which can also cause infection. Some infectious elements are presented here such as schistosomiasis, hookworm, ascaris, and tapeworms which might cause diseases in farmers (Parkinson et al., 2003).

4.2 Current Water and Sanitation Situation in Rafique Colony:

The most important resulting aspects of survey questionnaires about existing water and sanitation situation in colony are categorized. The households interviewed with their answers are presented in table 4.1 and supported with their views.

Each household revealed that WSS conditions had always been bad since the colony originated. Population was increasing day by day which caused rigid WSS conditions. People migrated from various parts of Pakistan and settled here because they wanted to avail good work opportunities in this city. Majority of respondents (9 out of 10) had their own houses and one respondent had rented the house. The service of Water and Power Development Authority (WAPDA) was available in one or two streets of the colony as seven respondents confirmed it. There was no concept of centralized system for WSS because of the non-existence of municipal services. Each household was responsible for arranging and managing these services by his own social and financial resources.

The following table 4.1 shows internal structure of research theme. It contains two types of detailed information which was gathered from response/views of inhabitants of the area about water supply within households and wastewater disposal system from household to end point with their associated components.

Table 4.1: Inhabitants’ response on questionnaires about current water and sanitation situation in Rafique colony

<table>
<thead>
<tr>
<th>Current water and sanitation situation in Rafique colony</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which methods are used for water supply?</td>
<td></td>
</tr>
<tr>
<td>Groundwater extraction at home</td>
<td>9</td>
</tr>
<tr>
<td>Bringing from some distance</td>
<td>4</td>
</tr>
<tr>
<td>Hand pumps installed at household</td>
<td>1</td>
</tr>
<tr>
<td>How is water stored?</td>
<td></td>
</tr>
<tr>
<td>Closed container</td>
<td>9</td>
</tr>
<tr>
<td>No container (Open small containers)</td>
<td>1</td>
</tr>
<tr>
<td>What do you feel about quality of water?</td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td>5</td>
</tr>
<tr>
<td>Dis-satisfied</td>
<td>5</td>
</tr>
<tr>
<td>What do you think about quantity of water?</td>
<td></td>
</tr>
<tr>
<td>Sufficient</td>
<td>7</td>
</tr>
<tr>
<td>Not sufficient</td>
<td>3</td>
</tr>
<tr>
<td>Do you boil water before usage?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>Which type of toilet is used?</td>
<td>Flush toilet (Pour)</td>
</tr>
<tr>
<td></td>
<td>Any other type of toilet</td>
</tr>
<tr>
<td>How is wastewater disposed of from household?</td>
<td>By un-solid drain (Open streams) to sludge pond</td>
</tr>
<tr>
<td></td>
<td>By proper sewerage line (Solid drain)</td>
</tr>
<tr>
<td>Is the wastewater system in household vulnerable?</td>
<td>Yes, broken pipes and blockage</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Where do you throw small solid waste particles from grey-water?</td>
<td>Directly flush down to drain pipes/ throw in streams</td>
</tr>
<tr>
<td></td>
<td>Properly disposed (separately)</td>
</tr>
<tr>
<td>What is the overall environmental condition of wastewater disposal of area?</td>
<td>The worst conditions (Improper)</td>
</tr>
<tr>
<td></td>
<td>Perfect (Proper)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
</tr>
<tr>
<td>Where does the sludge end up?</td>
<td>Piled Around pond/ Pass on to agriculture</td>
</tr>
<tr>
<td></td>
<td>No (Remain at its place)</td>
</tr>
<tr>
<td>Do you have idea of wastewater usage in agriculture?</td>
<td>The potential fertilizer/ Crops consumption acceptability</td>
</tr>
<tr>
<td></td>
<td>No Idea/ Not acceptable</td>
</tr>
</tbody>
</table>

### 4.2.1 Household Water Supply Sources & Storage

The methods of extracting groundwater varied. The electric motor was used to obtain water in most of the households. Nine respondents were using this method except one, he had hand pump installed in his house as shown in figure 4.4 and water was used by storing it in open small containers whenever required for cleanliness and other domestic purposes. In addition to electric motors: four respondents also used to bring water in small containers from a certain distance.
Nine respondents used closed containers (small Tanki) placed over the roof of house for storing extracted groundwater (Figure 4.5). The benefit of storing groundwater in closed container was to gather water for the whole day by using less electricity as shortage of electricity was a critical issue in the area. People got supply of electricity from their neighboring area because the
Crossing Street at some distance from the area had main supply of electricity. The high cost of electricity paid to the neighbors around 300-400 rupees per month for running electric motor pumps. All respondents were not satisfied with electrical supply except one who had hand pump in household.

4.2.2 Quantity and Quality of Water

Half respondents (5 out of 10) were satisfied with the quality of water; those inhabitants were adaptable to the quality of aquifer because no major illness has been experienced by water. Other half respondents were not satisfied with quality of water; they complained about distinct odor, color and taste in water. Some believed that the water of well at certain distance was bit better than available at home. Therefore, they used to bring from there as well. The quality of extracted water was not checked before using it in nine households because they were not aware of it and did not have time and energy. In one household, inhabitants boiled water when felt doubt about quality of water or children became sick. The quantity of water was sufficiently used for all domestic purposes in seven households. Three households did not feel it sufficient because of shallow boreholes and electricity shortages. A large amount of electricity was used to obtain limited water. The cost included boreholes being reconstructed many times incurring heavy expenditure. Therefore, they used to bring water from well installed at some distance to fulfill their domestic needs.

4.2.3 Household Wastewater Disposal System

The pour flush toilet (Shown in Figure 4.6) used in all ten households interviewed; no other toilet system was used. Toilet and bathroom were together as usual. Feces, urine, grey-water (bathroom/kitchen) and rainwater were drained collectively in main sewerage line of households which ended up in sedimentation pond via un-solid (open stream) drain prevailed in the streets as observed and all respondents confirmed it.
Solid waste particles such as food stuff and polythene bags especially from kitchen were commonly thrown in drain pipes which came into main sewerage of houses (Figure 4.7).

Polythene bags filled up with water and air in main sewerage which caused blockage. This was the view of all respondents. Another problem was that the wastewater disposal infrastructure within household was not sustainable to protect environment and health of inhabitants. Seven respondents’ complaint about broken pipelines, it affected fresh water supply pipes if they installed together. The low quality and improper installation of infrastructure caused contamination. The private sanitary worker is hired to resolve this problem for the time being. The pipes became blocked and wastewater pushed back on the floor of house which caused skin and other diseases. This blockage was cleared by inhabitants’ own effort because they did not want to call for sanitation workers because of cost issue. All agreed that the blockage in wastewater system of household occurred due to low quality of material used in drain pipes and habit of inhabitants to flush down solid waste particles from kitchen and bathroom. The reasons behind views of interviewees were as follow: low quality material was available in markets, un-affordability, lack of awareness and strong un-changeable habit of flushing waste particle in drain pipes of house. Three respondents did not complain about contamination caused by broken pipelines, low quality material and inadequate infrastructure within household.

4.2.4 Sludge Disposal & Environmental Conditions in Colony

Overall environmental conditions of area were bad; all ten respondents and observation confirmed it. There were frequent blockage, broken pipes, damaged main holes, odor and damaged house connections, overflow of streams/sedimentation ponds, and diseases.
Figure 4.8 Sludge was piled around pond and dried by sun in Rafique colony. (This picture was taken by author)

On this issue respondents were of different opinions; Five were saying that the sludge was removed from pond and piled around it most of the time (Figure 4.8) or passed on to other vacant plot or passed on to closest agriculture fields (Figure 4.3) or in main external drain of colony. This task was done by using extraction pump; a private sanitation worker was hired to do this and people used to pay for this service.

Figure 4.9: Sludge was not removed from pond in Rafique colony. (Original picture was taken by author)
Five respondents told that nothing was being done for sludge removal (Figure 4.9). Generally, the high temperature dried water in streams, and ponds but solid waste remained there. People were not aware of not throwing solid waste of household in ponds. Sometimes, they quarreled on this issue. The sludge was used as potential fertilizer for the production of vegetables (Figure 4.3) which people consumed. This was the view of eight respondents because of old tradition. Two did not have any idea about it. Important information was also gathered that the vegetables produced in this area were used in entire city and known to be the best.

Respondents were asked about their shared thinking for improvement of WSS conditions in the area; half respondents revealed that they were used to think about improvement and other did not think because they felt that there was no unity among people because of heterogeneity, lack of financial resources, and corruption in government authorities. A small group of households gathered and thought about improvement of sanitation situation of area; they were used to go to offices of WASA and political representative of area for this issue many times. The officials promised every time to resolve but nothing had been done till date.

4.2.5 Sanitation Workers’ Response:

The answers of questionnaires which were obtained by sanitation workers are categorized and presented in table 4.2 and supported by their views.

<table>
<thead>
<tr>
<th>Current water and sanitation situation in Rafique colony</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>When is sludge removed from ponds/streams?</td>
<td></td>
</tr>
<tr>
<td>Daily</td>
<td>2</td>
</tr>
<tr>
<td>Weekly</td>
<td>1</td>
</tr>
<tr>
<td>Monthly</td>
<td>1</td>
</tr>
<tr>
<td>Have you experience of clearing wastewater blockage in household?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>4</td>
</tr>
<tr>
<td>Yes</td>
<td>0</td>
</tr>
<tr>
<td>Do you identify point of contamination in drinking water?</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Where does the sludge end up?</td>
<td></td>
</tr>
<tr>
<td>Piled around</td>
<td>2</td>
</tr>
<tr>
<td>Thrown in open plot</td>
<td>1</td>
</tr>
<tr>
<td>External drain line</td>
<td>1</td>
</tr>
<tr>
<td>Sold to farmers</td>
<td>0</td>
</tr>
<tr>
<td>Do you suffer from diseases?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

Two respondents told that sludge was removed daily; other two revealed that the removal was done weekly and monthly depending on the situation and public demand because people paid for it. All four told that they did not remove blockage in wastewater pipes of household because people used to clean or remove blockage by themselves to save money. Sometime water supply and wastewater pipelines broke up which passed along within household and caused
contamination in fresh water supply. Three sanitation workers said that they did not sort out such problem. One said that people identified wastewater mixing with freshwater by distinct color, taste, and odor in water. Two respondents were in favor that sludge was removed and piled around pond or stream; one told that sludge is thrown in other free plot, and one told that sludge was disposed in external drain of area by using electric motor extraction pump. Sometimes, farmers also took extracted sludge directly from ponds. All respondents’ complained about diseases because degraded environment was their work place without proper protection.

### 4.3 Households' Response on Developed WSS model:

The table 4.3 shows the responses obtained from public about designed WSS model to achieve sustainability.

Table 4.3: Inhabitants’ responses on questionnaires about WSS model in Rafique colony

<table>
<thead>
<tr>
<th>Views on WSS model</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think about rainwater preservation technique?</td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>8</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
</tr>
<tr>
<td>No Idea</td>
<td>1</td>
</tr>
<tr>
<td>What do you think about reverse osmosis plant for purified water supply at their doorstep?</td>
<td></td>
</tr>
<tr>
<td>Agree</td>
<td>9</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
</tr>
<tr>
<td>What do you feel about grey-water treatment options within household and area (Screening, dual septic tanks, ABR system)?</td>
<td></td>
</tr>
<tr>
<td>Like</td>
<td>10</td>
</tr>
<tr>
<td>Dislike</td>
<td>0</td>
</tr>
<tr>
<td>Would you like to use black-water treatment option (DUDT and storage containers at household)?</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
</tr>
</tbody>
</table>

### 4.3.1 Alternative option to groundwater:

Eight respondents were interested to use rainwater for domestic purposes if the whole community accepted the concept. Most of them were not favoring or accepting this idea independently; it was felt that there was some kind of unknown hesitation among them. Two refused the idea; they said that we could not drink rainwater because it would not be of good quality with respect to religious perceptions. It was difficult for them to understand the concept. One did not have any idea about usage of rainwater. Inhabitants (9 out of 10) were interested to have WASA services for purified drinking water and they wanted to pay for the service cost. One respondent was not interested in this option; he complained that the cost would be higher than service quality of WASA because he did not trust on WASA. Respondents were unable to understand technology.

### 4.3.2 Health and Environmental Protection of Society

All respondents were interested to have WSS arrangements which could provide better environment in the area. Although, they did not understand technologies but they appreciated and agreed with designed arrangements of WSS for grey-water. This technical structure would
prevent blockage of wastewater drains, eliminate odor, improve environment and reduce diseases. A huge sedimentation formation would never be occurred in area; it would be easy for people to develop practice of removing solid waste particles from screen traps within household. Grey-water could be re-used in agriculture by using ABR system.

Un-reliable response about management of black-water was observed because people did not have ability to understand scientific significance. Majority of respondents around (7 out of 10) did neither understand nor had an idea about it. They did not like to discuss in detail.

4.4 Responses of WASA Officials:

This section presents information about views of WASA officials about implementation process for WSS project in peri-urban areas like Rafique colony and important hurdles faced in that process.

4.4.1 Response of First Official:

First official gave basic information as follow:

- WASA did not provide services to all peri-urban areas.
- Some colonies were being provided by WSS services within each union council.
- A newly developed colony wanted to have WASA service; first of all the area should get NOCs (No Objection Certificate) from all services providing authorities such as WAPDA, Faisalabad Development Authority (FDA), WASA and TMA. Those colonies without NOCs were considered illegal as in the case of Rafique colony under UC-272.

He referred to his senior official for further information.

4.4.2 Response of Second Official:

Senior official also started his views from similar information as first official gave and continued as follow:

- The major criteria for WASA to provide services as previously outlined;
- Customer should meet designed WASA tariff which was some amount of money depending on land size of house.
- The sources used to supply water were canal, seepage, and groundwater. The treatment plants were installed on canal which was located 25 km away from city area to provide safe drinking water to the whole city; seepage water could not be treated.

The major challenges to provide services to every small colony under UC and failure of approved projects were as follow:

- No integration among all stakeholders, limited financial and technical resources, shortage of staff, low recovery rate, lack of awareness in general public, and people were not willing to pay for the service of WASA.
• The trend of using water cans provided by private vendor was illegal because WASA had authority to stop them all. By law the international quality standards were available but existed quality of water in Faisalabad was not up to the mark. Water act 2011 was developed for implementation for groundwater sustainability in peri-urban areas with no WASA services; the people would not be able to install private electric motor pumps at houses in those areas for unlimited extraction of groundwater only hand pumps would be allowed.

• No integration among all stockholders for instance all municipal authorities such as FDA, TMA and WAPDA did not co-operate with WASA for implementing any WSS project which caused hurdle to provide the same level of services regarding water for poor community. WASA had been planning to provide equal standard quality of water cans to each area at low cost. Unfortunately, the suggested idea might remain unsuccessful because FDA might not convince and allow WASA to provide this type of water in specific areas because illegal land structure.

• The sustainable arrangements of wastewater system similar to defined in model such as separation of grey-water and black-water were discussed in benchmarking for sanitation quality conference. In which the standards of sanitation in other countries compared and presented with Pakistani. The foreign consultants from Japan requested to develop and implement improved system as presented in benchmarking conference. They had conducted survey in Punjab and considered Faisalabad as pilot project site.

• Unfortunately, corruption in WASA with political influence was the major hurdle to implement any sustainable WSS project.

• The dishonesty of developer of colony has also played vital role not to get proper services because he sold land area for houses at full cost by promising buyers that proper WSS facilities would be available in future. He did not fulfill his promise because he wanted to hide tax in revenue from government authorities.
5. Discussion:

The discussion section presents two major aspects: overall challenges of area/ obtained from empirical study and suggested strategies to improve WSS system in Rafique colony and similar peri-urban areas of Punjab.

5.1 Overall Challenges:

Some important challenges to provide safe WSS services obtained from empirical study are as follow: Inhabitants wanted to have safe drinking water and sufficient quantity of water at their household to meet their domestic needs. They also wanted that sanitation system in household and area should be capable of protecting environment and health. Unfortunately, they were adapted to use the destructive WSS system. It is assessed that it would be difficult for them to change their habits corresponding to new suggested arrangements. The adaptability to black-water treatment arrangements was big challenge including designed toilet system because it was observed that majority of inhabitants was unable to understand the technologies. The lack of awareness and cultural perceptions were major reasons to cause such challenge. The current sludge usage for agriculture fields was causing vulnerable environment. Another important challenge found was that WASA was unable to supply WSS services in illegal land structure like Rafique colony. Some internal issues within WASA existed which also caused hurdle for WASA to proceed with successful implementation of projects.

5.2 Strategies for WSS Improvement:

5.2.1 Water Supply Arrangement at Household

The rainwater is jointly disposed of with other wastewater from household in open drains and sludge pond without proper management and as a result flood situation occurs, a large amount of rainwater is wasted as well. This issue has been identified and all respondents confirmed it. The rainwater preservation technique suggested (Figure 2.1) in WSS model (Figure 2.7) which can be installed at individual household to preserve rainwater without mixing it into wastewater of household. Five respondents complained that the existing aquifer quality is bad because of distinct color, odor, and smell. The shallow bore holes and load shedding were common issue in focused area because of not having other reliable options as respondents told. Therefore, these problems will also be resolved by suggested option if rainwater is preserved properly, the aquifer and rainwater can be utilized in balancing way. National drinking water policy (2009) also supports suggested idea as follow: rainwater should be collected and preserved at household level which could increase water supply for domestic use and groundwater recharge. Although, people were unable to understand technical structure of scheme but eight respondents were agreed to use rainwater via suggested option for all domestic purposes except drinking; other respondents were not agreed because of lack of knowledge or awareness and religious perceptions. Unfortunately, the maintenance and cost aspect of the system were not accessed. But, they are important aspects which need to be considered in future.
5.2.2 Safe Drinking Water Supply for Colony

The quality of aquifer is degraded because pathogenic transmission to aquifer through stagnant wastewater in streams and ponds in area (Figure 4.2). Inhabitants were adapted to this quality of aquifer. Nine respondents told that they were used to extract groundwater for all purposes including drinking without quality testing because they were not aware of it and having less energy resources. One respondent was used to test quality before using by boiling it when their children became sick or they had any doubt about it. Four respondents were used to bring limited amount of water from well at certain distance because they felt it better than local aquifer. This technical solution based on reverse osmosis (Figure 2.2) is identified in WSS model (Figure 2.7) because it has been proposed for a peri-urban area in Faisalabad by WASA. Therefore, it can be suitable for focused study area as well. Nine respondents were agreed to have good quality of water supply provided by WASA and pay the cost. In this way, safe quality of water could be equally provided to each inhabitant of colony at their doorstep in controlled manner.

5.2.3 Household Grey-water Management

All solid particles from grey-water (Kitchen and bathroom) are flushed down with other wastewater from household because of improper infrastructure, low quality material and lack of awareness as all ten respondents confirmed it. Simple screen and grease traps (Figure 2.3) as a treatment tool for grey-water within household suggested in WSS model (Figure 2.7) which can eliminate solid particles from grey-water disposal points. Drangert & Tonderski (2010) emphasize its significance for treatment. The task of removing solid waste particles filtered from screen and grease trap over drain points can be done easily by inhabitants. In existing system, people are used to open blocked pipes in household by themselves to save money as all four sanitation workers revealed. Therefore, inhabitants can develop habit of removing solid particles extracted out if guided properly by various social means. In this way, the solid particles and polythene bags will never pass through the screen and grease traps of drains so they will not encounter with other wastewater to cause degraded environment. The effluent with limited solids will flow down in drain pipes of household without exposure to environment. This option is cost efficient and easily accessible in society.

5.2.4 Household Black-water Management

In existing system, black-water with other wastewater of household is directly disposed of in streams and ponds with inadequate management as it was observed. Pour flush toilets (Shown in figure 4.6) are used in households as all respondents told. Unlimited water is wasted in these toilet systems. Deegener et al. (2006) reveals that a person produces about 500 liters of urine and 50 kg of feces in a year. It shows that a large amount of water is contaminated with fecal pathogens than quantity of human waste. A large and expensive sewage system is required to manage wastewater in such toilets; nutrients are also lost. Therefore, DUDT type system (Figure 2.4) is suggested in WSS model (Figure 2.7) which can collect and convert fecal material in potential fertilizer at household. Ministry (2006) supports that the ventilated pit privies latrines connected to septic tank and further connected to wastewater collection system should be designed in un-served area (Peri-urban). Reduce, reuse and recycle will be encouraged on all levels to separate wastes for getting maximum resource conservation. WASA can collect and sell
that produced fertilizer to farmers and compensation can be given to households. NGOs like Anjuman Samaji Bahbood (ASB) can promote the usage of system in general public via door-to-door awareness program because awareness among people about usage/ scientific importance will be required for adaptability because seven respondents have not understood the concept during survey.

5.2.5 Grey-water Management at Colony Level

The concept of septic tank (gutter) has already prevailed in one or two streets of Rafique colony as observed, which collects all wastewater from several households and forwards it in main external crossing sewerage line. In majority of streets, there is no septic tank which can handle wastewater for proper disposal. The option of dual septic tank (Figure 2.5) suggested in model (Figure 2.7) can gather screened grey-water from several households. Some tanks can be installed in each street to collect that grey-water from households and further forwarded to ABR system (Figure 2.6) on area level. Each ABR system can further treat grey-water supplied from several dual septic tanks in a street. It can also work well in the place of sludge pond as Drangert & Tonderski (2010) emphasizes such arrangements. Although respondents were not able to understand technical system, they appreciated possible consequences of this arrangement. Sanitation workers revealed that sludge is removed from ponds daily, weekly, and monthly. Therefore, sanitation workers of WASA can remove sludge from dual septic tanks and manage ABR systems in this colony. These techniques of treating grey-water do not require energy for efficient operation. The treated grey-water can be supplied to agriculture farms or utilized for some other purposes.

5.2.6 Management of Untreated Wastewater Usage in Agriculture

Untreated wastewater or sludge is supplied to agriculture farms located around Rafique colony as observed (Figure 4.3) and five respondents confirmed it so the agriculture environment also causes bad health impacts for residents and farmers. The designed model can treat feces and urine to convert into potential fertilizer at source place (household) as mentioned (Section 2.3.4) and transfer to agriculture fields. It can prevent degraded environment of agriculture farms where untreated wastes is used. Human feces contains average amount of 0.5 kg nitrogen, 0.2 kg phosphor and 0.17 kg potassium annually. A large amount can be used as soil conditioner instead of fertilizer due to high humus concentration and low nutrient (Deegener et al., 2006). For feces treatment, Drangert (2010d) points out that many pathogenic organisms select their respective organisms. The viruses, pathogenic bacteria and parasites have ability to select species for infection. These reactions guide to explain the process of re-use of excreta in agriculture. The two types of fertilizers are produced by treating excreta. These fertilizers can be categorized and used for production of the crops which can be consumed by human and animals. Deegener et al. (2006) also point out the usage schedule of urine for agriculture. It contains many nutrients such as nitrogen, potassium and phosphorus, which are essential for plant production. The nitrogen content in urine acts like artificial fertilizer so it can be dangerous for plants if applied in too high concentration. Undiluted urine should be applied to plane soil before sowing plants; when plants have started to grow then water diluted urine with ratio of 1 to 4till 10 should be applied. The workers perform such treatments and farmers should be aware of existence of human pathogen in fertilizer after the treatment. Farmers can be provided proper guidelines for these identified
conditions (Section 2.3.4 and Figure 2.4) of using fertilizers in agriculture to protect agriculture environment.

5.2.7 Strategies for Government Authorities:

All Government institutions providing municipal services based on priority as urban, rural, and peri-urban parts respectively in Faisalabad are centralized. WSS services are not provided to majority of peri-urban areas within UC and known to be illegal as confirmed by WASA official. Ministry (2006) states that WSS facilities shall be provided and distributed to all poor and rich settlements on equal level; the most vulnerable areas based on social and environmental conditions will be given priority. To achieve such objective, the concept of decentralization and quota of resources can improve and make informal settlements more visible to authorities. The poor communities in peri-urban can get allocated resources, services, and legal rights of votes for election as urban and rural parts have; it will solve WSS issues as well. The local government can allocate resources by their annual development projects for achieving Millennium Development Goals (MDG); some donor institutions such as Kushali Bank and Pakistan Poverty Alleviation Fund (PPAF) can also provide funding for sanitation specific projects (Ministry, 2006).

To implement designed model (Figure 2.7) efficiently, strong legal framework for WSS system shall be developed and implemented via concerned authorities. Provincial government will approve laws for developing sanitation, sewage, and wastewater treatment system in developing colonies depending on sizes and TMAs will monitor implementation of those laws. The developers of such colonies will also have to obey those laws; they will be given incentives and municipal disposal points for underground sewerage construction (Ministry, 2006).

The component sharing model will be used in all government projects for rural or urban areas where population is more than 1000. The wastewater treatment and sewage will be provided by large schemes in those areas where disposal developed by local government is not available. The households in community where people have built their own sanitation systems will be given incentive to make attractive component sharing model; this idea was implemented in Orangi, Karachi via OPP and in Bader colony Lahore via CPP. The cost of O & M will be covered by getting various charges from local users of area (Ministry, 2006). These policy guidelines can be implemented in Rafique colony as well because it has suitable situation as follow: appropriate population and the developer of this colony has neither paid the cost of WASA to get service nor constructed waste disposal system so this area has remained disconnected as WASA official confirmed. The initial cost of WASA (land size of house) for providing services in area and cost of physical structure including technical products can be considered as loan which can be paid partially by each household on monthly basis. The treated wastes from households can be collected by WASA and households will be given incentives against fertilizer produced; the cost of that fertilizer can also be adjusted in monthly bill. In this way, people will have to pay low cost bills for good services. Few houses in colony which already have relatively better WSS infrastructure or have affordability to install will be provided incentives.

Some hurdles to implement WSS project in these areas are revealed by WASA official as follow: there does not exist integration among stakeholder, limited technical staff, and low collection of revenue, limited technical and financial resources. The efficient working of institutions require institutional capacity building which will make human resource development via providing special training for co-operation among institutions. The involvement of private sector with
public can help measuring quantity of services. A contractual framework will be developed to involve private sector. For instance, many private companies are providing services and efficient technologies for different projects of WASA as official told. The efficient technologies used in model (Section 2.3) can be arranged by public-private partnership. They are culturally feasible for society because similar products: such as dual septic tank, pour flush toilets similar to designed DUDT, and closed big containers for water which can be used for black-water storage, have already existed in market. A little modification in those products will be required which private company can make.

A standard benchmark such as International Benchmarking Network for Water and Sanitation Utilities (IBNET) is used to monitor and evaluate services for WSS; it is integral element of project life cycle. WASA official response also confirmed that the sustainable arrangements of sanitation suggested in model (Figure 2.4 & 2.7) was presented in an international conference about the benchmarking for sanitation quality. The provincial government should take full control of WSS project including funding for such areas. The involvement of local political leaders should be very limited to reduce corruption because their personal interests influence whether a project would be successful or not which becomes major hurdle in existing system as confirmed by WASA official. Public survey emphasized that smaller group of people are formed in area because of heterogeneous population which caused hurdle to get their collective benefit from authorities. Therefore, the awareness about social unity can be added in door-to-door awareness program and provided to public of Rafique colony by NGO like ASB.
6. Conclusion & Recommendation:

Water and sanitation conditions in peri-urban areas of Faisalabad are destructive as found in Rafique colony. A critical threat to human life is result of vulnerable WSS situation. The social unity among inhabitants of area is found to be limited because of heterogeneous structure of society. Therefore, the collaboration between public and government authority does not work well. In this way, such area remains hidden from the vision of government. Government authorities are unable to resolve these problems because of their internal organizational problems. The empirical findings reveal that quality and quantity of water are bad in study area because of sludge ponds and inadequate wastewater disposal system; sanitation system from household to area is unable to prevent environment and health of inhabitants. The components associated with water supply and grey-water treatment suggested within model can be successful to this particular society which can resolve all water supply and grey-water disposal problems. The black-water treatment options can be considered good within the model. In reality, this option is remained unclear or unsuccessful because of socio-cultural barrier. A simple strategy is suggested to overcome this hurdle such as door-to-door awareness program for usage of this system. A strategy for social and financial development is defined for provincial government with policy support. It can resolve internal organizational problems and help government to legalize and provide better WSS services through designed model in those areas. If these strategies are implemented successfully, this model can be used as role model for all other peri-urban areas in Punjab.

The pilot study suggests few outcomes for future development for specific case study as follow: The details of technologies involved in WSS model were difficult to explain to the interviewees by using simple questionnaires. It might be because of their low level of knowledge and understanding or improper explanation and interpretation. A local female co-worker should be involved who can enter the household to observe the internal structure of WSS system; she could also communicate with females at their specific level of understanding to explain details of technologies within household and get real views of females about important aspects of WSS system.
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Appendix I: Questionnaires for Inhabitants of Rafique Colony

Water and Sanitation Situation:

Could you please tell me something about development of your area?

Which methods are used for water supply?
- Groundwater extraction at home
- Bringing from some distance
- Hand pumps installed at household

How is water stored?
- Closed container
- No container (Open small containers)

What do you feel about quality of water?
- Satisfied
- Dis-satisfied

What do you think about quantity of water?
- Sufficient
- Not sufficient

Do you boil water before usage?
- Yes
- No

Which type of toilet is used?
- Flush toilet (Pour)
- Any other type of toilet

How is wastewater disposed of from household?
- By un-solid drain (Open streams) to sludge pond
- By proper sewerage line (Solid drain)

Is the wastewater system in household vulnerable?
- Yes, broken pipes and blockage
- No

Where do you throw small solid waste particles from grey-water?
- Directly flush down to drain pipes/ throw in streams
- Properly disposed (separately)
What is the overall environmental condition of wastewater disposal of area?
- The worst conditions (Improper)
- Perfect (Proper)
- Other

Where does the sludge end up?
- Piled Around pond/ Pass on to agriculture
- No (Remain at its place)

Do you have idea of wastewater usage in agriculture?
- The potential fertilizer/ Crops consumption acceptability
- No Idea/ Not acceptable

**Households’ Response for Developed WSS Model**

What do you think about rainwater preservation technique?
- Agree
- Disagree
- No Idea

What do you think about reverse osmosis plant for purified water supply at their doorstep?
- Agree
- Disagree

What do you feel about grey-water treatment options within household and area (Screening, dual septic tanks, ABR system)?
- Like
- Dislike

Would you like to use black-water treatment option (DUDT and storage containers at household)?
- Yes
- No
Appendix II: Questionnaires for Sanitation Workers

Water and Sanitation Situation:
When is sludge removed from ponds/streams?
- Daily
- Weekly
- Monthly

Have you experience of clearing wastewater blockage in household?
- No
- Yes

Do you identify point of contamination in drinking water?
- No
- Yes

Where does the sludge end up?
- Piled around
- Thrown in open plot
- External drain line
- Sold to farmers

Do you suffer from diseases?
- Yes
- No
Appendix III: Questionnaires for WASA Officials

Could you please present water and sanitation changes in Peri-urban area under the control of WASA during last five years?

Does WASA provide water and sanitation services to all Peri-urban areas in Faisalabad?
- Yes
- No

Does WASA provide services to all small colonies existing in union council 272?
- Yes
- No

Rafique colony under union council 272 does not have WASA services, would you please explain the reason?

Which criteria does WASA use to provide services to Peri-urban area?
- Initial cost of taking over should be paid
- Areas near existing infrastructure
- Other

From which source water is supplied to Peri-urban areas?
- Canal
- Lake
- Groundwater extraction
- Private wells
- Other

How is the quality of water assured before supplying communities?

An increasing trend of using water cans supplied by private vendor in the whole area of Faisalabad, What is your opinion about it?

The groundwater is excessively used for domestic purposes in Peri-urban (Rafique colony) because of not having municipal services, How could the sustainability of groundwater be achieved in your opinion?

Would it be possible for WASA to supply the same quality and quantity of water to all areas in order to lower the cost of water for the poor? (Above question no 1 is also included here)
- Yes, because
- No, because

The main drain of area collects wastewater from kitchen, bathroom and toilet from households; would it be possible to separate them from sources?
- Yes, How
- No, Why
The wastewater is flowed through open drains and ends up in sedimentation ponds which cause vulnerable health of children, how the health can be protected?

What are the hurdles for WASA to implement any sustainable project in Peri-urban area like Rafique colony?