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HOUSEHOLD LEVEL WATER RECYCLING FOR NON-POTABLE REUSE: A STUDY ON MUJGUNNI RESIDENTIAL AREA OF KHULNA CITY, BANGLADESH

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Abstract
The paper examined the possibility and of reusing household's grey water for non-potable uses as a means for reducing fresh water demand. The study was done in one of the planned residential areas of Khulna city where water demand and consumption is higher than other haphazardly grown areas. The study used two databases and other secondary materials, collected from relevant organizations. In addition personal communication has been made with concerned personnel. The study found that the residence of the study area get 46% supply water compared with only 20% in the whole city. Availability of water increased water consumption up to 300 litres per day per household. A significant amount of water (90%) is used for bathing, washing and cooking. Both the shower and kitchen water goes straight to drainage system to be more polluted with other toxic wastes. On the other hand, supply system is entirely based on ground water and absence of demand management techniques, over-extraction of ground water has been observed. Khulna city and surroundings have been facing salinity and arsenic contaminations in ground water, making it too vulnerable to provide fresh water to its 1.5 million citizens in coming years. Water treatment still remains uncovered in Bangladesh and authorities repeatedly had gone for capital intensive ground water extraction. Keeping in mind the ease, affordability and available technology, dual-reticulated recycling method is thus advised where the grey water will go again for toilet flushing and gardening after minimal treatment. It was assumed that the system will bring the half of the household waste water into use which will eventually reduce demand for fresh water.
Keywords: water recycling, residential area

1. INTRODUCTION

Urban services including water supply are in acute shortage. Due to its geographical location, both the surface and ground water in major parts of the city is saline. Moreover, construction of Ganges Barrage in Indian side reduces water flow in main river systems and increase salinity (Ahsan, 2012). Barrages controls by India to all of the tributaries to the Ganges divert roughly 60% of river flow (Pender, 2008). By the 5th largest dam in the world, average monthly flow by to Bangladesh was reduced by 86% (ibid). Salinity problem becomes wide spread in the dry season. Khulna city do not have any surface water sources due to mismanagement and lack of perceptive planning and regulation. Thus ground water remains the main water source for the city. Only about 6% city residence use surface water (e.g. ponds,

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canals) for non-potable uses. Overexploitation of ground water led to arsenic contamination which becomes viral. Almost all of the KCC area is moderately arsenic affected (KDA, 2001).The gross population density of Khulna city is 67,994 per sq. km and a large number of people are involved in informal activates (KCC, 2013). The city also characterised by lower level of revenue earnings, resulting poor municipal resource base. Revenue earnings through holding tax were only 22% (KDA, 2001). Daily water uses by households in Khulna city were found as high as 192 liter in the city core whereas it is much lower in urban fringe and municipality area, 112 liter (Alam et al, 2009). A significant amount of the water is used for single purpose-bathing took near the 50 percent of total use in city areas. On an average, a household spent near about 80 liter for bathing (Alam et.al, 2009). This huge volume of water goes straight to drainage system to be more polluted with other toxic wastes, fails to draw attention of the concerned authority.

The paper searched for alternative mechanisms to reduce dependency on ground water. Household water demand, consumption pattern and wastewater generation has been explored. The study also seek to explore possible vulnerabilities of future ground water reserve and advocated for a household based recycling system to make efficient use of water. Recommends were made to make the system affordable at household level, for concerned authority while approving building construction and for public awareness on sustainable water use.

2. A REVIEW ON WATER CRISIS, CONSUMPTION, SUPPLY AND DEMAND MANAGEMENT

A large proportion of population concentrates in small and large urban centers of low- and middle-income countries of them most at risk due to the effects of climate change — as lives, assets, environmental quality and future prosperity are threatened by the increasing risk of storms, flooding, landslides, heat waves and drought and by overloading water, drainage and energy supply systems. Cities are believed to be the first to be affected due to climate change. Overexploitation of resources and abandonment of natural system has made the cities, according to Kalr and Trenberth (2003) a 'concrete jungle' which effects on effects on heat retention, runoff, and pollution, resulting in urban heat islands.

World Urban population are increasing rapidly with a 3% annually since 1950 and is expected to be doubled by 2050 (WHO, 2013). Vorosmarty et.al (2000) studied on the global water availability and challenges in the age of high population densities in urban areas.

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They concluded that much of the world will face substantial challenges to water infrastructure and associated water services. It is thus assumed that cities will have to adopt hi-tech options to meet up extra demand. Much of the world urban population will live in developing countries, mainly due to high rural to urban migration rate. Between 1995 and 2005, the urban population of developing countries grew by an average of 1.2 million people per week, or around 165 000 people every day and By the middle of the 21st century, it is estimated that the urban population of these counties will more than double, increasing from 2.5 billion in 2009 to almost 5.2 billion in 2050 (WHO, 2013).

The challenge is not the availability of water but providing safe water. Over 25 million people in Bangladesh do not have access to an improved water sources (WaterAid-UK, 2013). Water sector lacks insightful ideas and mostly governed through capital investment. Al-Jayyousi (2003b) argued that most of the water project in developing countries are supported from external sources and failed to sustain after withdrawal of aid. Thus water management under current and coming stresses need to be more innovative.

There are a number of social and economic model of household water consumption. A social model developed by Gregory and Di Leo (2003) emphasized environmental behavior where awareness (i.e., issues, knowledge and opportunities) affects unreasoned (habits and reflexes), and reasoned (i.e., involvement, attitudes, intentions, perceived self-efficacy) influence. Furthermore, behavior is also affected by situational influences (e.g., socioeconomic, household and physical environmental variables). This model has been tested with residents of Shoalhaven, Australia. They have found that environmental awareness, personal involvement, habits and demographic characteristics (e.g. income, age, education and household size) have some predictive ability for household water consumption.

Water consumption also said to be influenced by hours of living in home, age related diseases (Green, 2003 and Russac et al., 1991 in Memon and Butler, 2006;).

Affluence also is a key factor in influencing water consumption. It was found that water use in urban residence and high quality houses in developing countries are more than double of the suburb and rural areas (Stephenson, 2003 in Memon and Butler, 2006). Water uses thus have a strong positive correlation with affluence and geography.

However, there are still some factors that believed to have influence of water use and yet to be exposed. Less discussed but potentials factors would be number of children in a household and weather in a particular location. Countries in tropical and subtropical areas can have high demand of water for frequent washing purposes.

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A most recent study on peri-urban water security in Khulna was done with a focus on identifying the climate vulnerability of water sources and adapting techniques of local people (Kumar et al., 2011). This research took into account the institutional arrangement of water supply and going to provide a community level coping mechanism. However, no indication of demand management or water recycling was given to the scoping report.

Earlier, in 2010 Asian Development Bank has conducted a city wide study on water supply with a view to finance in the water supply sector through KWASA. Water demand management and repairing water leakages were recommended along with core economic solution like construction of reservoirs and ground water management (ADB, 2011b).

Eventually, KWASA has taken a project which proposed a surface water system which will distribute water through a system of storage reservoirs and overhead tanks. Authorities are still interested in large physical investments rather that soft policies of supply and demand management. Vairavamoorthy and Mansoor (2006) argued that water supplies in most developing countries are supply driven where shortage of supply embraces capital investment. These kinds of practices, as UN-HABITAT (1999), quoted in Vairavamoorthy and Mansoor, 2006:) concluded create impediments on taking innovative approach for demand management. A number of demand management approaches have been prescribed by Vairavamoorthy and Mansoor (2006) like water pricing, subsidies, wastewater reuse, water metering etc. Soft side demand management approaches e.g. institutional capacity building, public awareness has also been proposed (ibid).

Several studies have found that organization led demand management approaches were not successful. As for example, water pricing is considered to have influence on consumption but the belief has more recently been dispelled by the research from Worthington and Hoffman (2008); Barrett, (2004).

They demonstrated that in most cases residential water demand is largely price inelastic because of its low relative cost when compared to other life essentials (Worthington and Hoffman 2008; Barrett, 2004 cited in Wills et al. 2011b). Darby (2010) studied efficiency and applicability of smart metering for reduction in demand and costs but got little evidence in demand reduction. However, she concluded by saying that metering could influence demand reduction if a strong strategic intention from the authority and social support was ensured.

The potentials of decentralized water recycling were not understood in Bangladesh though it is very much common in Australia and USA and developing countries like Malaysia. UK still has the low rate of

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implementation but from 2016 all buildings are to be constructed according to the highest level of the code, the internal per person daily water use has to be less than 80 liters suggested in Codes for Sustainable Homes (Environmental Agency, 2011).

Majority of consumers (63%) do not pay water bill by volume which also a reason for low level of grey water recycling in UK. However, in recent years, a number of studies have been done on application of household greywater reuse in UK and Ireland e.g. in Ireland (Li et. al, 2010) and Birmingham eastside (Maunsell, 2004). Study carried out at southern France, among 400 municipalities found it that the choice of a water-pricing structure is a complex exercise, involving trade-offs between cost recovery, equity, and environmental efficiency (Rinaudo et. al, 2012; p 2067).In their study (Short, et. al, 2012; p 1954) on water system in Australia, 60% responded opposed to price increase as a tool for demand management. Around 80% responded that they had installed water saving devices. About 61 percent were in favour of authorities responses in installing water saving equipment. The study also stressed on community awareness regarding efficient water uses.

3. METHODOLOGY

Data were retrieved from two databases (Khanam, 2010 and KDA, 2012) containing household socio-economic as well as water related information of the case study area and whole Khulna city to get data about water supply, use and wastage etc. Khanam (2010) Studied on water supply status of Mujgunni residential area and KDA (2012) conducted socio-economic household survey under the and sample survey under Detail Area Planning (DAP) for Khulna Metropolitan area.

Urban and Rural Planning Department of Khulna University was a reliable sources of data in forms of dissertation, project reports on water supply system of Khulna city. KWASA had been preparing water supply master plan which was another source for current planning proposals.

The research was carried out on Mujgunni Residential area as a case study. The justifications of selecting this area are:

I. The area is one of the few planned area in Khulna city which has piped water supply coverage.

II. The area is the residence of high and middle income groups and building structures are permanent and multi-storied.

III. Piped water allows people to consume more and consumption is higher in middle and higher income group.

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IV. Unlike other spontaneously grown areas, construction of buildings in this area requires planning permission.

Two databases that were used in this research were analyzed in IBM SPSS statistics 19 environment. Some ungrouped data were converted into grouped (recode in SPSS) data for ease of analysis and comparison. Findings from databases were then reinforced by literature survey. Understanding life cycle of waste water and volumetric analyses were essential before proposing recycle system. This was done by Process flow study to map out water uses at household level and destination of wastewater. It has been previously established that the attitudes and beliefs of consumers directly impact on water use behaviors which are closely linked to water demand (Hassell and Cary, 2007 in wills et. al 2009). Thus, study on consumer behaviour and attitudes were as important as numbers. Moreover, Consumer's opinion, perception and feelings towards water supply helped to evaluate performance of relevant organizations. Future planning proposals are also interpreted in light of people's opinion to examine the consistencies of the proposals.

4. STUDY AREA DESCRIPTION

Mujgunni is one of the seven residential housing projects completed by Khulna Development Authority. KDA took this project in 1980s and completed in two phases. Residence's socio-economic conditions suggest that Mujgunni belongs to high and middle groups of people. It is located about 4 km. away from the Central Business District with proper arterial road connection.

The area was planned as a low density area. The sources of domestic water supply in the study areas include piped treated water supply, which is pumped from the WASA wells, community tube well/tap from DPHE/NGO and individual/self-dug tube well as private source. Mujgunni residential area was constructed on 67.71 acres of land and divided into about 771 plots of different size. Almost all the houses are permanent, brick and concrete structured and multi-storied.

More than half of the buildings have 4-6 dwelling units (54.7%), 19% buildings have more than six units. Rest of the buildings have up to 3 units. About two-third units have 4 rooms indicates relatively large families (4-6 members comprises 72.4%) which is higher than Khulna city average (3.8).

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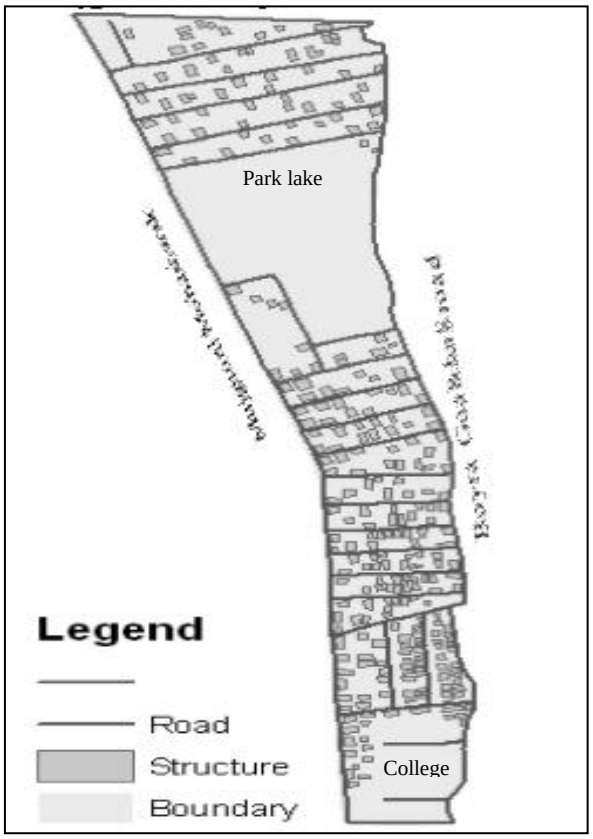

FIGURE 1 - STUDY AREA FOOTPRINT
Source: Modified and updated from Khanam and Al-Mansur, 2011

Residents largely fall in middle and higher income groups (BDT 20000 or more) in respect to the national average income (BDT 11,479) (BBS, 2010). Average earnings of Top 5% household are BDT 35,659 and bottom 5% households earn BDT 5,149 per month (BBS, 2010). Three quarter of the households living in a rental basis. However, a significant number of households have been living in the area for comparatively long period of time.

Findings and Analysis

Current Water Supply System

Total length of piped network in Mujgunni is 2448 meters. Water is channeled from the water pump station to households through 200 mm diameter pipe whose length is 1286 meter. And 150 mm diameter pipe of 1162 in total length. From these mains, water are distributed to households by 18.75 mm pipe.

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Besides, community shallow and deep tube wells provided by Khulna City Corporation and Department of Public Health and Engineering (DPHE) in different parts of the area is the major water source for drinking purpose in the study areas. There are 12 tube wells in Mujgunni. These 11 deep and one shallow tube well in Mujgunni serves 291 people to fulfill their existing water demand (only for drinking and cooking purpose) (Khanam and Al-Mansur, 2011). Another most prominent water source is self dug shallow tube well in the household premises for private use despite having piped water connection because of poor water quality and inadequate supply. As much as 52% dwellers in the study area have this dual system.

Water Consumption Pattern

Despite having piped supply, all the residents of the study area relies on hand pumped tube well for drinking and cooking purposes. Supply water used for bathing and washing purposes. One most important reason for not using supply water for drinking and cooking is that the water quality is not satisfactory. Lack of regular maintenance in the supply system and unresponsiveness to the consumer demand and problems, people become sceptic about the quality of water. In addition, people can dug shallow tube-well in their premises, having fresh water they can rely on.

TABLE 1 - WATER USES FOR DIFFERENT PURPOSES IN THE STUDY AREA

Sources of Water	Purpose of use (% of respondents)			
	Drinking	Cooking	Bathing	Washing
Piped water supply	-	-	50.4	50.4
Community Tube well	67.7	66.2		
Private/self-dug tube well	32.3	33.8	49.6	49.6

Table 1 show that a typical 4-5 member household spent 165 litre water per day on an average for bathing and washing purposes. In present system, there is no mechanism to hold this water for reuse. The major concern is that almost half of the households used fresh underground water from private tube well for bathing and washing. It indicates that almost half of the drinkable water is being polluted and wasted.

TABLE 2 - WATER CONSUMPTION PATTERN IN THE STUDY AREA

Water use	Purpose of use				Mean household water use per day
	Drinking	Cooking	Bathing	Washing*	
Mean	10	12	98	67	**187**
Maximum	15	8	150	125	
Minimum	5	6	50	40	

*including toilet flushing but how much consumed for toilet flushing is unknown

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Water requirement for toilet flushing and sanitation

This research uses the databases lacks quantitative data for sanitation purpose alone. However from previous studies, breakdown of water uses for bathing, cooking and sanitation purposes can be possible. Gleick (1996) analyzed water uses both in industrialized and developing countries and suggests basic and average needs of water for different purposes.

TABLE 3 - WATER REQUIREMENT FOR DIFFERENT PURPOSES

Purposes	Average in developing counties (person/litre/day)	Minimum requirement (person/litre/day)	Average household size in the study area	Water uses per household
Bathing	15-25	15	4	60
Cooking	10-20	10	4	40
Sanitation	-	20	4	80
				180

Source: Gleick, 1996

From the minimum requirement, a household of four will need 180 litre of water per day. However, Gleick (1996) as well as UN proposes to international organization and water supply agencies to adopt a 50 litre per person per day water to meet drinking and these three needs irrespective of climate, technology and culture (IFAD, 2013). In core city areas in Khulna, the daily water uses per household, in fact, is 190 litres (Alam et al., 2009).

Wastage and attitude

The study reveals that households have piped water waste more. To a certain level this can be proved. Consumption as well as wastage is highly related on availability of supply. Water consumption and wastage in planned residential areas in Khulna city is higher that spontaneously grown areas. Consumption is one fifth higher in planned residential area but the wastage is more than double (Khanam and Al-Mansur, 2012). A chi-square test has been done to understand the phenomenon in detail. The research hypothesis was 'households with piped network/private sources waste more'. As the households use only piped/running water and private tube well, consumption tends to be higher with the availability of those sources.

Association between water uses for bathing purposes and availability of source shows a higher significance level (99.9 %). In addition, strength of the association was tested by Cramer's V and it is 0.225, which, according to Acton and Miller (2002; p 149) can be considered as strong association for social science studies. Moreover, cells with adjusted residuals value greater than 2 and less than -2 should be given special priority while examining the form of association.

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As the other sources are absent, full fledge comparison is not possible. However, the value of adjusted residuals suggests that people also uses more water with the presence of private water sources. Water for washing purposes, did not show any sharp differences as washing is a 'must-to-do' job for households.

A Brief Overview of Existing and Future Water Supply Plan

For Khulna city, one of the major challenges is to provide water to its citizen. The water is saline in most of the parts of the city. In 2007, Khulna Water Supply and Sewerage Authority (KWASA) were formed to look after the water sector. However, presently 10% of total households are under the water network coverage (KWASA, 2015).

Remaining parts of the city have taken different measures to fulfill the water demand. Historically, neither the city corporation nor the KWASA had the capacity to serve water for drinking and other purposes. Thus different actors get involved in water supply sector in the eve of growing drinking water scarcity and demand. There are about 157,375 households in Khulna city and only 16000 households have the water supply connection through supply network (BBS, 2011 and KWASA, 2015). A large number of households are getting water from KWASA deep tube-well, individual pump and number of agencies engaged in water supply for decades.

Under these circumstances, KWASA has been implementing a project since 2011 with the technical assistance from ADB and JICA to upgrade its supply network from 282 km to 600 km. The water will solely be collected from surface water sources and delivered to households.

However, there are much uncertainties and challenges to get the aspired result from the project (for detail analysis, see Salauddin, 2013). KWASA recently introduced 5000 water meter where monthly water charges varies from BDT 70 to BDT 300 (Less than £3) and installation charge is BDT 1200 (£10) (source: personal conversation with KWASA). The proposed water charges thus would have no significant differences.

Water metering is the only mechanism adopted to put restriction on water consumption by KWASA. However, success of this mechanism entirely dependent on consumer behaviour and authority would have to control in the demand management system.

Moreover, studies have found that imposing higher tariff make no difference in water uses among the higher income groups (Kaika, 2006; p 161). In extreme cases, higher income groups can consider charge hikes as a route for avoiding social responsibility and moral obligation against excessive water

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use. They will have the ability to pay more to use more water, might neutralize the spirit of water metering.

5. ALTERNATIVE APPROACHES

Increasing population is one of the major concerns which in one hand putting pressure on available limited natural resources and on the other hand, pollution and management failures become more evident. KWASA's plan for increasing water coverage and adoption of new water sources are expected to be effective in providing better services although organizational, financial and climatic factors became more challenging.

Success of the proposed integrated system depends on perspicacious and efficient implementation. However, the project and plans KWASA have taken are mostly technical in nature and ignores the participation and probable contribution of people in plan making and implementation. The system, if successfully implemented, water will be more available to the people.

Current consumption pattern suggests that more water availability would contribute to more uses and eventually produce more waste water. It is presumable that the future piped network would connect middle and high income groups in the first instance. Water demand for washing and bathing is reasonably high in those groups.

Above discussions calls for an urgent action to save water and incorporate consumers in the total water distribution systems. People need to be motivated and authorities should be responsive. Along with water metering, reusing water at household level would eventually decrease the water demand which will let the authority to redirect water in the unserved areas of Khulna city. The proposed system will be more efficient and appealing if associates with a recycle system with the existing water supply system to hold back the wastewater for further use.

As the city does not have dual water supply system to channel the water for treatment, a household level recycling method can be implemented. The system would allow the household to be more cautious about the water use and bring significant changes in drainage system and water reserve.

Authority will work on through plans and policies to make the deal lucrative and harmonize the total water supply system.

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Design Recommendation

Based on the findings, this study proposes a dual piped water supply system where wastewater will be stored in the basement and later the water taken to the rooftop water tank for supplying water to toilet flush and other non-potable use (e.g. car wash, gardening, outside cleaning).

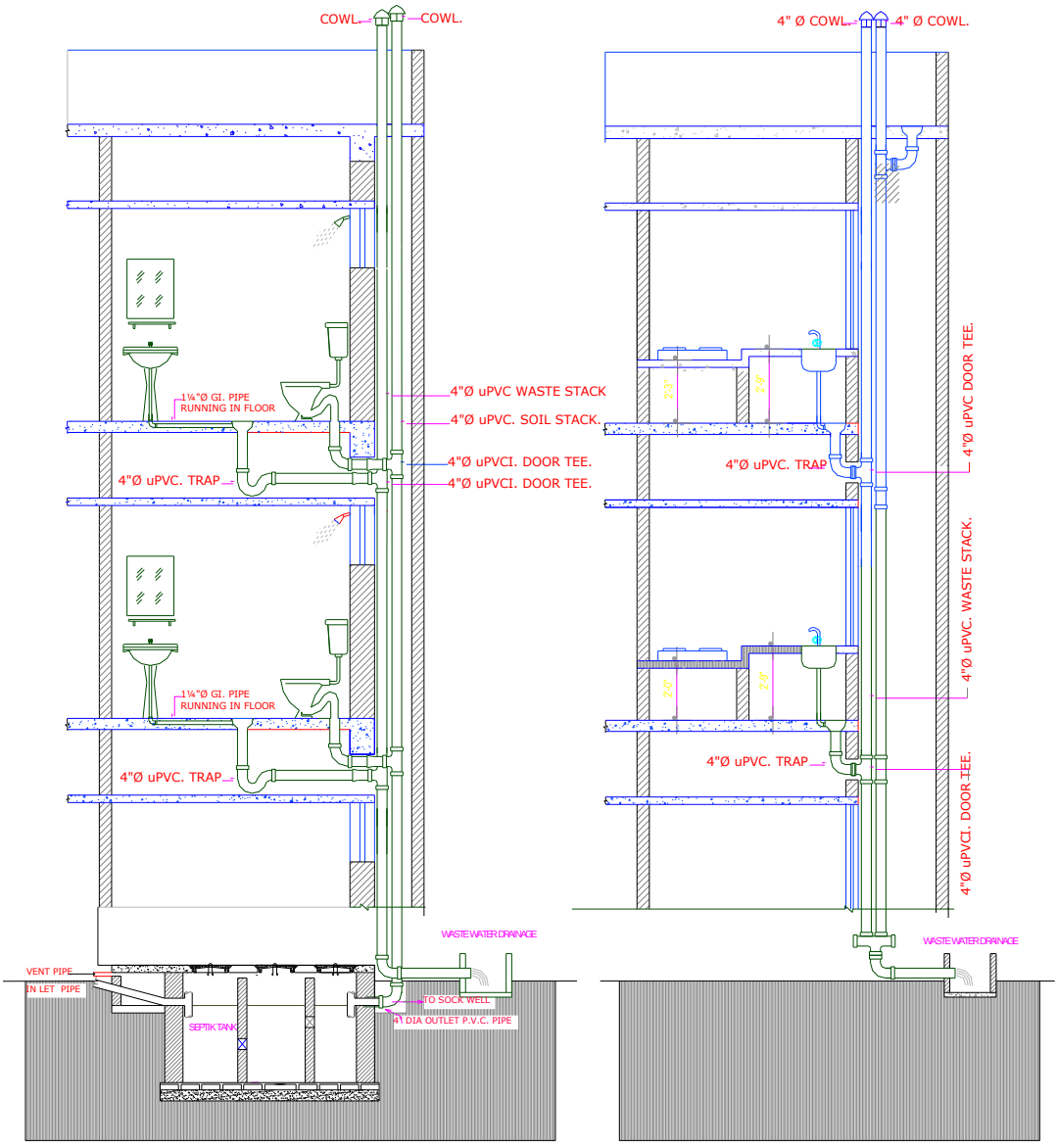

FIGURE 2 - EXISTING WASTEWATER COLLECTION SYSTEM

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In the existing plumbing system (figure 2), Shower and kitchen waste water are carried through pipe only to discharge in the drainage system. With some addition piping arrangements, these large volumes of water can be stored for non-potable uses. Building structure in the study area is suitable for the recommended design. Almost all the buildings in the study area are at least two-storied (91.5%). Toilet, shower and kitchen will have different piping system to collect the waste water (figure 3).

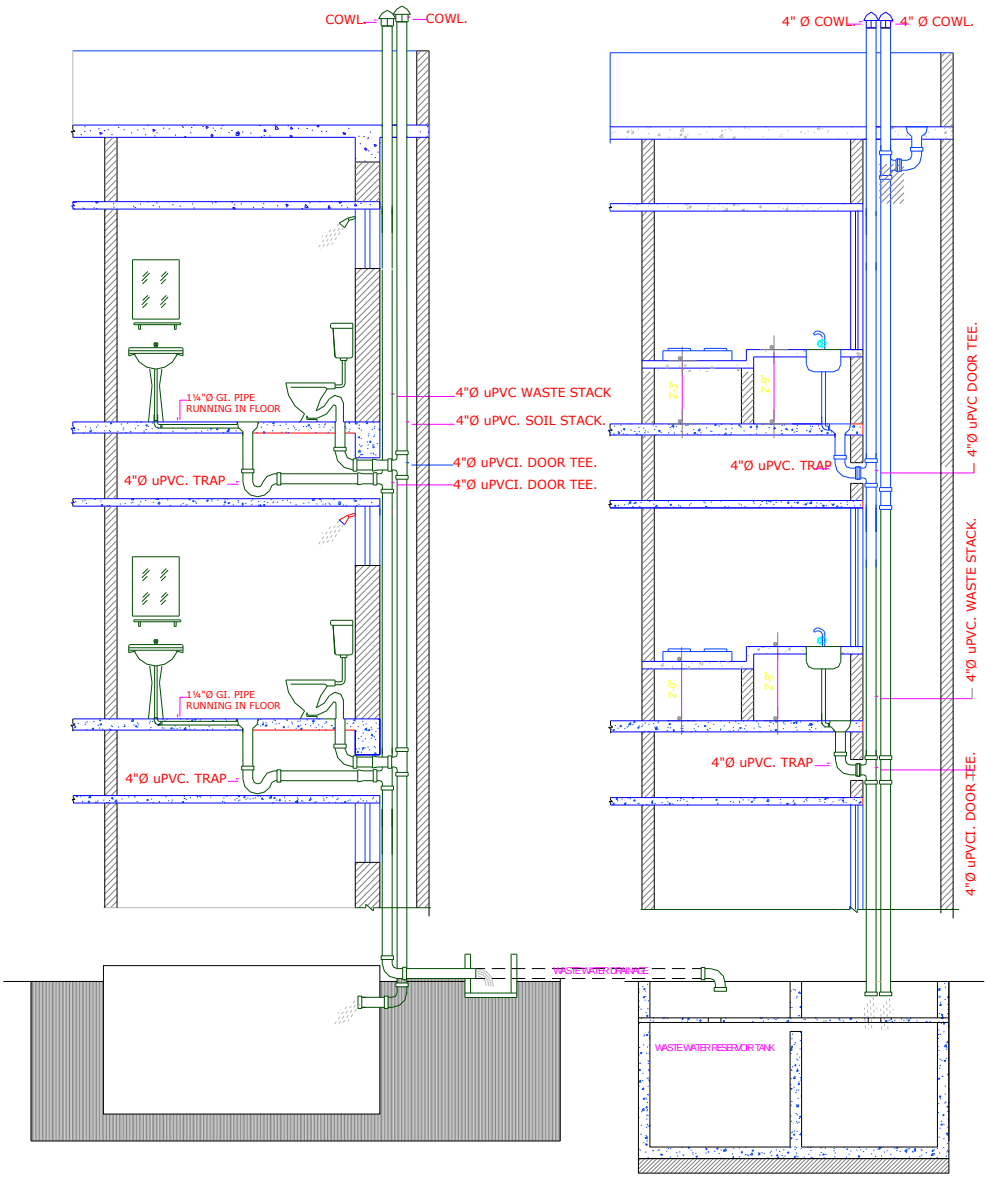

FIGURE 3 - PROPOSED WASTE WATER COLLECTION SYSTEM

A new basement storage tank will be constructed where waste water from these two sources will mount up. This storage tank will have two separate chambers to allow suspended solids in the waste water settle down and enter the next chamber. Then the waste water will flow across another small

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rectangular shaped chamber filled by small brick/small rock particles and sand (figure 5). This chamber will work as filter bed which will rectify the water holding finer suspended solid and germs. This system can effectively reduce germs and solid from the waste water as the system will run continuously round the clock. The rectified water will then store up in a small tank from where water will be transported to rooftop water tank.

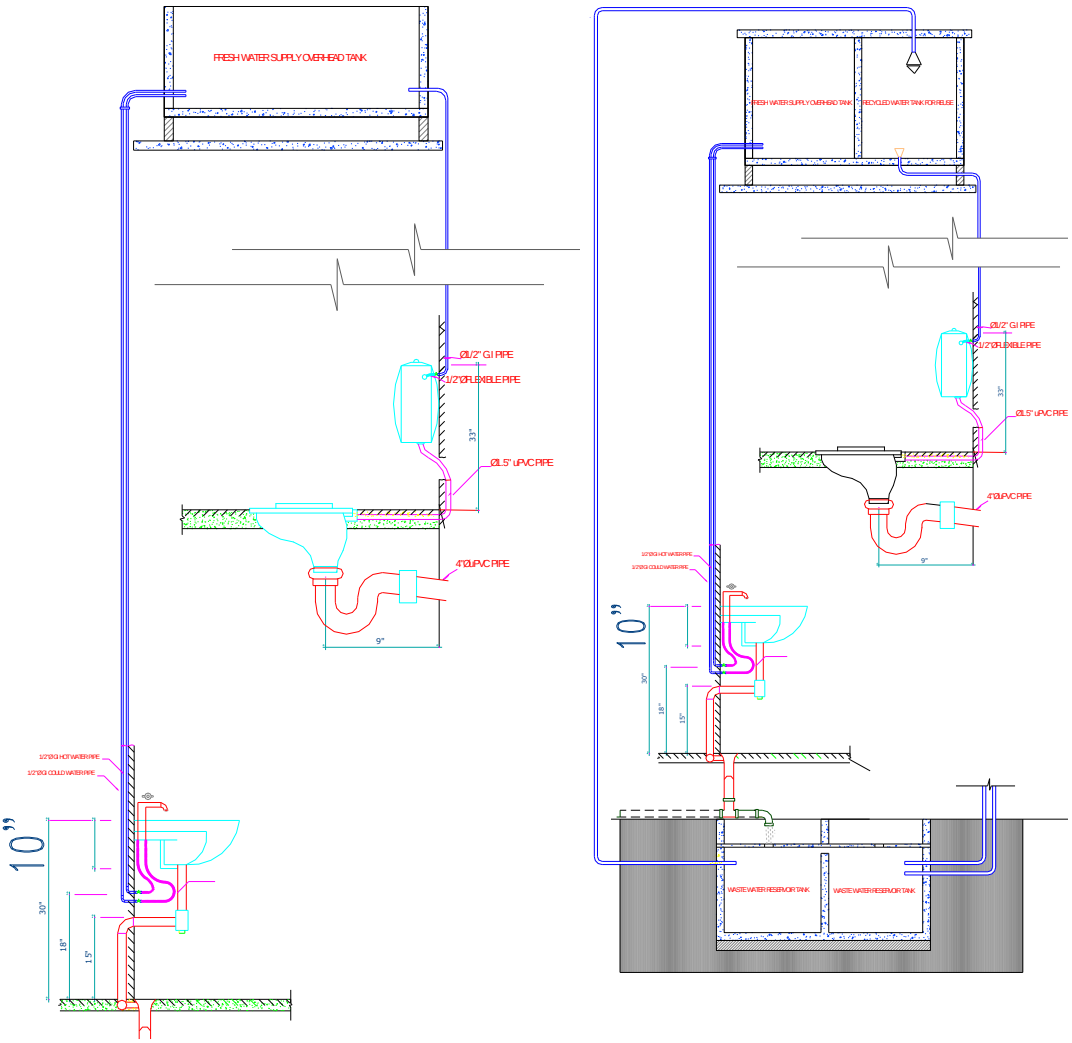

FIGURE 4 - SECTION OF THE EXISTING AND PROPOSED WATER SUPPLY TO TOILET AND KITCHEN FROM OVERHEAD TANK

The rooftop water tank will have a separate chamber allows two types of water flow in two separate piping system (figure 5.6). An additional outlet will be taken to the basement from the recycled water tank for washing and gardening purposes. Layout of the basement or underground recycled water reservoir and the connection system is highly case specific, will depend on quantity of wastewater, plot size and building materials.

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A Wide variety of options, however, are available to make the system more pathogen free. Water Aid-Bangladesh, with the technical help from Centre for Science and Environment (CSE), India has implemented a number of community based projects in Tangail and Khulna. Though CSE has implemented the techniques successfully in different institutions and community, the total system can be squeezed into the basement of a building (http://www.cseindia.org/node/3798 and Salauddin et al., 2012).

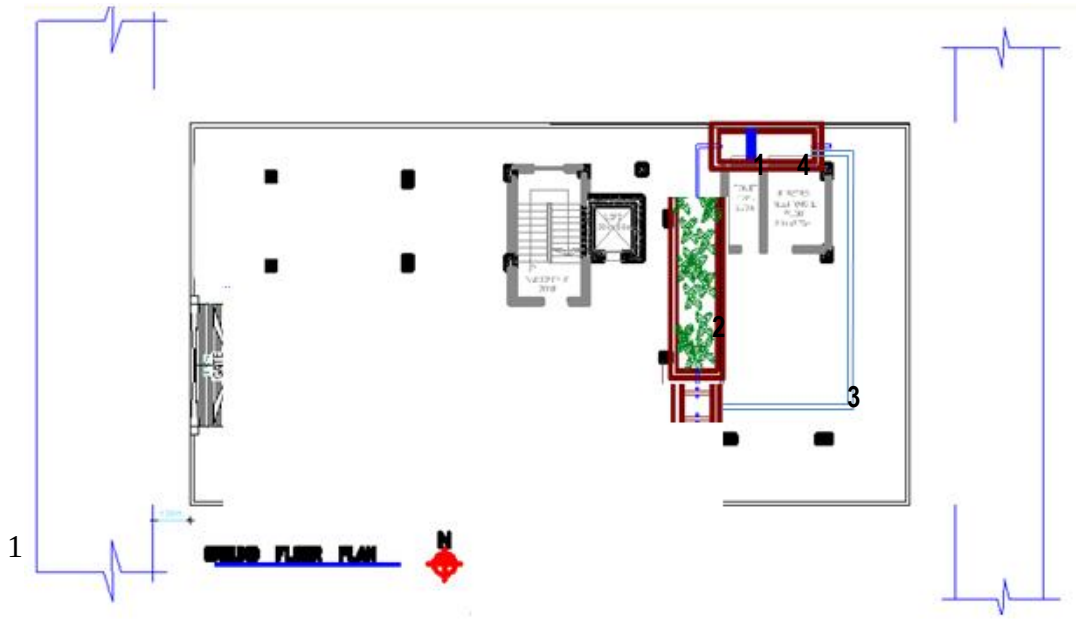

FIGURE 5 - PLAN OF THE BASEMENT/UNDERGROUND RESERVOIR TANK AND NATURAL RECYCLED SYSTEM

Nevertheless, the proposed recycling mechanism could face a number of challenges. Cities of Bangladesh are densely population and land is scarce. From the technological point of view, recycled waste water can be beyond of non-mechanised treatment after several reuse. The necessity of regular maintenance can be act as a disincentive for the households. But the continuous research and successful application of this kind of recycling system in different parts of the world brings hope to cope with the most scares resources.

Implementation mechanism

The proposed system will require several focused institutional responses as well as collaboration from consumers. The whole process should have to be managed by KWASA, with continuous consultation with KCC and KDA in plan making and implementation. Implementation mechanisms that might be in action are discussed below:

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Institutional arrangements in plan making and implementation

Current segregation in plan making and isolated implementation should be synchronized by responsibility sharing within the common goal of city development. Organizations will share their aspiration in plan making. While providing water connection, KWASA will seek building approval letter from KDA and vice versa. KCC, as a local government will work closely with community people to make the system acceptable. KCC, KWASA and KDA should endeavour towards capacity building, an essential step for better implementation of Plans. Currently the organizations are running with manual record keeping which is a major impediment in collaboration. It also restricts civil society and people from information and decrease the transparency of service providing organizations. A central record keeping system is necessary taking into consideration the three important areas of management such as transactional activities, operational activities and management control.

Municipal Tax discount

Properties are charge annually by KCC in the name of holding tax. While approving new building plans, KDA will consult with the applicant to include a recycling system by offering tax rebate for a certain period of time, depending on the building type and capital involvement. However, KDA is now not in a position to impose the system because the rate of application for building plans approvals are quite low. Further strict regulation might have negative impact on plan approval process. Adopting of recycling system would be a 'carrot approach' in the first instances and gradually moved to 'stick and carrot' approach. The plan approval committee in KDA would consist of member form KCC and KWASA. The amount of tax rebate against each application would be recorded. The short term losses of KCC from tax rebate can be compensated from water charges.

Restructuring Housing Loan

Bangladesh House Building Finance Corporation (BHBFC) and scheduled banks are giving loans to individuals for constructing houses. Before sanctioning loans, financial institutions seek building construction approval letter from concerned authority. Thus, KDA can amend their building regulations and work closely with the applicants to install the recycling system for speeding up the loan approval process. Organization agreement between KDA, KWASA and financial institution are required. Interest rates for the loan can be lowered for those plans having recycling system. High recommendations can be made available to the financial institutions for those building plans. To monitor the process, total loan amount can be distributed at different stage of the building constructions.

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Financial and logistic supports from KWASA

KWASA proposed a new connection charge applicable to all buildings. It is assumable that houses without any recycling system would consume more fresh water. KWASA thus, can propose a different connection charge and monthly water tariff higher than the houses will have install recycling system. Moreover, connection charges can be divided into affordable instalments over a certain period of time. To help consumers and make them familiar with the system, KWASA will have a logistic division for water recycling. It would help the building owners design their building with efficient recycling system. In addition, KWASA will work with the already constructed buildings owners in installing recycling system. Once installed, maintenance of the system will be done by the owner of the house and costs will be shared by the tenants with the monthly water charges.

Awareness Campaign and Community Involvement

Community involvement and awareness campaign is crucial in mainstreaming water recycling. Professionals e.g. Architects, Planners, Engineers need to be motivated. Prejudice and conservativeness towards wastewater reuse needs to be eliminated through proper consultation with consumers and community people. Awareness regarding water crisis and citizen's responsibilities towards water use behaviour should be highlighted and publicized through appropriate media (e.g. workshops, trainings and guiding documents).

6. CONCLUSIONS

The study aimed to identify alternative solution to reduce over-extraction of ground water and wastage of water in a city where water is scarce and most of its residence did not have sufficient safe water. Consideration of demographic attributes along with existing qualitative and quantitative assessment of water supply services illustrates that the surface and ground water resources are in vulnerable position by overutilization, exploitation and ignorance. Piped water network was inadequate. Water supply authority assumed that their proposed extension of pipeline and surface water sources would increase the supply after the plan period. However, without efficient demand management, the situation might get worse. Increasing urban population will struggle to have safe water. With limited resources and unseen negative environmental externalities, rethinking in providing water services is urgently important. The study proposed a household level water recycling system as a tool for demand management. The system would enable households to retain the wastewater for reuse. Recycled water will be used for non-potable uses where fresh water was being used. Some implementation mechanisms have been

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proposed in context of Khulna city. It was believed that the system would help building awareness among people in prevailing adverse economic and environmental situation as well as help building consensus in securing resources for sustainable development.

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