Potentiality of DWTS (Decentralized Waste Water Treatment System) in Informal Settlements: A case of Hrishi Para, Khulna.

Debnath Nipa
(MScHS-190103)
Department of Architecture, Khulna University. Khulna-9208.
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Abstract:

Like most cities in developing countries, Khulna is experiencing rapid urbanization leading to an increase in the urban population and rapid growth in the size and number of informal settlements. A large number of the city's population resides in these settlements, where they experience inadequate and poor quality urban services including sanitation and wastewater management. Providing reliable and affordable wastewater treatment in urban areas is a challenge in many parts of the world, particularly in developing countries (May A. Massoud, 2008). The decentralized approach of wastewater treatment which employs a combination of on-site systems is gaining more attention because of flexibility in management, cost effectiveness and simplicity. This paper presents a study of decentralized approaches to wastewater treatment and its potentiality in informal settlements. The informal settlement (Hrishipara) is selected for the study and used a mixed method approach for data collection. The research found that residents experienced multiple problems because of poor sanitation that's why this study tries to find out the potentiality of "DWTS" in this settlement to solve that problem. While there are many impediments and challenges towards wastewater management in developing countries, these can be overcome by suitable planning and policy implementation. Management strategies should be site specific accounting for social, cultural, environmental and economic conditions in the target area. Findings from this study can be used by the city authorities in the planning of effective wastewater management intervention strategies for communities in informal settlements.

Key words:

Potentiality, Decentralized Waste Water Treatment System, sanitation, Informal Settlements.

Introduction:

Sanitation and wastewater management is one of the major aspects of an urban area which has paramount importance on the quality of life and the environment (UNDP, 2016). Development of population and urbanization has resulted in increasing the wastewater management problem. Like most of the developing countries, Bangladesh is also experiencing rapid urbanization leading to an increase in the urban population and rapid growth in the size and number of informal settlements. The formation of a large number of slums is where service inadequacies on sanitation and drainage have been compounded and multiplied on a massive scale, resulting in a hazardous environmental condition (Aime Tsinda, 2013). Urban water systems face multiple challenges (Nancey Green Leigh, 2019) related to future uncertainty in the environment and livelihood. Residents of these informal settlements seek better living standards, larger amounts of freshwater are supplied for the domestic use, which generate greater volumes of wastewater (Lazarova and Bahri, 2005; Qadir et al., 2007a; Asano et al., 2007). Commonly wastewater is discharged with little or no treatment in natural water bodies, which can become highly polluted. This practice can severely harm human health and the environment (Qadir et al., 2007b). To achieve sustainable urban water, wastewater management is a significant sector of development which leads to a healthier life (Telmo, 2002).Many government and non-government organizations are working together in this sector all over the world to achieve sustainable urban development.

In Bangladesh, 57.7% of people in the urban area have access to sanitation facilities (BankWorld, 2016) that meets the WHO/UNICEF Joint Monitoring Program (JMP) definition of improved. The problem of informal settlements remains one of the greatest challenges for city managers. Rests are still using a unhygienic toilet which are connected directly with drain. The wastewater from the toilet and household management system is a major and indispensable issue to be solved.

In Khulna, third largest city of Bangladesh with 1.5 million people, the population is growing faster than the provision of services. A large number of the urban growth has taken place in informal settlements. There are about 1134 slums in Khulna City Corporation (KCC) area that comprise 8.14% of the total area (Bangladesh Ministry of Planning, 2015) . According to the JMP definition there are a very small number of improved sanitation, a big percentage is using unhygienic sanitation. Pit latrines in the informal settlements are often poorly maintained and rarely emptied; the pits are generally not lined with bricks and can collapse after a period of use (Hohne, 2011). there is a possibility to empty liquid from pits, the sludge is not always disposed of in a proper manner. Also there is a number residents spatially children are use to open defecation. Ultimate al of theses human waste goes to direct in drain or water body.

Figure 1: Human waste discharge direct to the drain (d) Domestic Sewage discharge

Khulna City Corporation (KCC) along with various Non-Government Organization (NGO) are proving sanitation service in many slums under different sanitation projects. But the sanitation projects fail in some cases and cannot meet the demand and expectation of slum dwellers (Md. Shaharier Alam, 2019). Hirishi para is one of the slums of Khulna city where personal sanitary latrines are hardly found and three household use one toilet there. The community sanitary latrines has provided by NGO Nobolok very recent. But due to numerous difficulties such as resource problem, lack of skilled manpower and new technology, corruption, nepotism, lack of coordination etc especially in informal settlements and poor unplanned areas. these latrines fail to fulfill the demands of slum dwellers and as a result, the sanitation status degrades in the slums which endanger both health and living environment of the urban area.

This situation might be improved if Khulna was equipped with a sewerage system. However, unlike other cities in Bangladesh, which have networks of sewer pipes and treatment plants to cover a small percentage of its inhabitants. In Hrishipara therefore cannot afford a centralized sanitation system because of the high cost of the associated physical infrastructure which includes a network of pipes, land ownership and maintenance. This raises a pressing need to understand the nature and magnitude of the issues affecting sanitation provision in order to find more cost-efficient and sustainable sanitation alternatives to address them. Innovative decentralized sanitation and re-use systems were developed partly in opposition to centralized ones and there have been claims they are more robust, cheaper and better able to deal effectively with environmental challenges (Sano, 2007). Whichever technologies are used, they must be context appropriate and cost effective to the low-income dwellers (Tilley, Morel, Zurbru, & Schertenleib, 2008) of developing cities. However, to the best of our knowledge, no research has been undertaken on how current on-site problems can be solved by the use of other on-site or ‘mixed’ technologies that match with the context of informal settlements of Khulna.

It is against this background that this article aims to analyse the challenges faced by people using the existing sanitation systems and find out the potentiality of DWTS in terms of wastewater treatment, operation and maintenance; and frame sustainable sanitation systems that match with the local conditions of informal settlements of Hrishipara. The findings will contribute to providing the basis for policy makers to make informed decisions on which sanitation systems fit for informal settlements of Khulna, and other major cities.

Methods:

The study was conducted in Hrishipara, informal settlements in Khulna which was purposely sampled because it has some of the poorest sanitation facilities. The settlement is also characterized by high levels of poverty, high rates of illiteracy, high unemployment, poor housing. Other characteristics of this area include poor drainage systems, poor sanitation facilities, the unauthorized building of extensions, and the high density of settlements with steep slopes and wetland areas.

A mixed method approach was used. This included transect walks through the settlement, a household survey, focus groups discussions and key informant interviews. The study team started an unannounced transect walk with an informal talk with a few community members and then continued the walk to observe the condition of sanitation facilities and waste water management system as well as any evidence of open defecation around the house and backyards.

The household survey, collected quantitative data on sanitation facilities and income using a structured questionnaire. The survey sample was selected through random route sampling techniques in proportion to the population of the study area. It was conducted between July and October 2020. The survey questionnaire was pilot tested before being administered in the communities, and all the staff involved with the survey were trained before use. About maximum households (95%) were interviewed giving a non-response rate of 5%. The head of household or another adult (18 years and over) answered the questionnaire on behalf of the household.

The findings of the survey were supplemented by the qualitative research, undertaken to find out the potentiality of DWTS in this settlement. Focus group discussions and in-depth interviews were used to capture the informants' perspective and allowed for more in-depth information on waste water management and helped us to better understand what was going on and why. This is important because in various fields of science, voices have been raised that research should be done with people and not on or for people (Chevalier & Buckles, 2013). Decentralized Waste water management is an example for such a setting and thus in order to define sanitation technology options with a high chance of long-term success, a thorough understanding of the needs and concerns of residents (own occupiers, tenant, landlords) is essential.

This qualitative work in Hrishipara yielded a rich data set. This article draws primarily on two focus group discussions conducted with owner occupiers, two focus group discussions with tenants (half female and half male) who were the head of households but excluded local leaders and resident landlords. Survey data were analyzed using mapping, JMP method and fishbone

analysis. The data collected through focus groups discussions and in-depth interviews with key informants was transcribed and analyzed thematically. In order to improve the validity of the data, a triangulation strategy was used. This strategy involved collecting information from a range of sources (household survey, transect walks, focus group discussions, interviews).This has the advantage of filling weaknesses or gaps in data for one method, which results in strengthening the overall quality of the results. Ethical approval was given by Ethics Committee of University of Surrey. Participation in this study was voluntary and all respondents gave verbal informed consent to their participation in the research.

Definition of DWTS:

Decentralized wastewater management may be defined as the collection, treatment, and disposal or reuse of wastewater from individual homes, clusters of homes, isolated communities, industries or industrial facilities, as well as from portions of existing communities at or near the point of waste generation (Battilani et al., 2010). DEWTS applications are based on the principle of low - maintenance since most important parts of the system work without electrical energy inputs and cannot be switched off intentionally (Butler and MacCormick, 1996). It is a sustainable communal wastewater treatment solution for urban areas where no wastewater management system is available (Al-Muyeed, 2016).

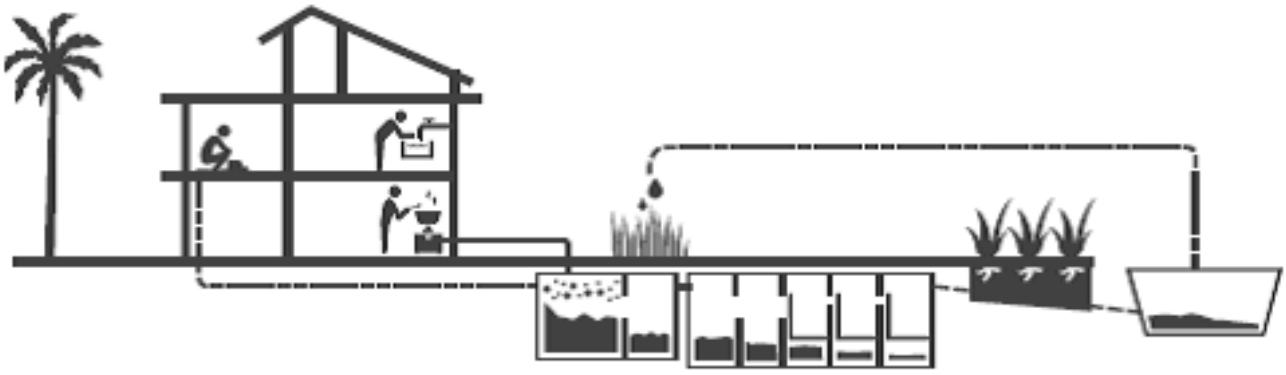


Figure 2: Recycling the waste water through DEWATS

The main advantages of DWTS systems are summarized below:

- DWTS systems can be constructed according to influent wastewater characteristics.
- It can treat wastewater from different sources such as residential structures, Hospitals, Schools, Markets, Hotels etc.
- Demand lower primary investment costs as no imports are needed.
- Require lower maintenance costs.

- Can provide efficient treatment of wastewater flow up 1000m3/d.
- Tolerant towards inflow fluctuations.
- Reliable and long-lasting construction design.
- If properly managed, these systems can meet discharge criteria.
- Provide effective solution for ecologically sensitive areas.

Components of DWTS:

Decentralized system is the combinations of aerobic and anaerobic treatment process (Feng et al., 2013). The anaerobic treatment process comprise of settlers, baffle reactors and anaerobic filters. The aerobic treatment process has horizontal/vertical/combine planted wetland and a polishing pond/surface flow constructed wetland (Figure 1). The basic idea of that is to treat the wastewater on-site by means of low-cost treatment systems, and make environmental friendly discharge of effluent according to standard.

The four steps of DWTS are_

a) Primary treatment: settlers or septic tanks)
b) Secondary treatment (anaerobic baffled reactors)
c) Tertiary treatment (subsurface vertical flow and / horizontal flow wet land system)
d) Additional tertiary treatment (polishing ponds or surface flow wetlands)

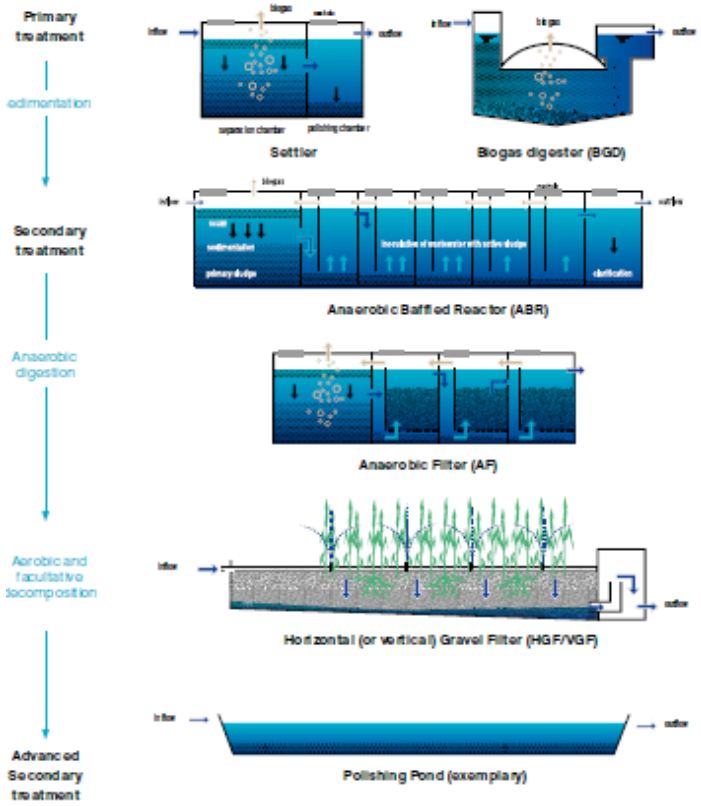


Figure 3: Treatment module of DEWATS

Effect on livelihood due to decentralized wastewater management:

- **Environmental**: Obviously DEWATS is a concept to improve our sanitation system and in a word very important to protect environment from our daily waste.
- **Economic**: it is a very economy friendly concept to bring our sanitation system in a environment friendly procedure.
- **Physical:** by using DEWATS concept it is possible to improve our livelihood and a sustainable sanitation system which ensure a better physical environment.

Treatment of wastewater in small settlements:

The wastewater treatment is a low-cost technology to control environmental pollution. The system is especially suitable for small settlements (Akca, 2000) . The control and/or construction of wetland ecosystems for water pollution control is relatively new technology. Although wetlands have been created incidentally by humans throughout history, the intentional construction of wetlands to provide habitat and water quality functions together began with the environmental movement in the 1970s (Kadlec and Knight, 1996). The constructed wetland technology offers a low cost, low maintenance solution to domestic wastewater treatment especially suitable for developing countries. Considering the uncontrolled expansion of big metropolitan cities of Bangladesh (e.g. Dhaka, Chittagong, Khulna) it is expected that this technology may offer a suitable solution for the small settlements or individual houses in suburban areas of the large cities as well as for rural settlements. This modified constructed wetland system ensures the removal of Chemical Oxygen Demand (COD) at satisfactory level in smaller area than usual systems. The experiments have showed that efficient nitrogen and phosphorus removal also can be achieved. This cheap and small treatment system might be especially suitable for small settlements and individual houses with a small garden.

Example of DWTS in Khulna:

Khulna is the third largest city in Bangladesh which is known to all as an industrial area. Most of its industries such as Jute mills, News print mill, and Hard board mill are situated in Khalishpur, Khulna. In the past, khalishpur was very busy and crowdie area when mills were active. To meet up the accommodation of factory workers a total of eight building were constructed at Peoples jute mill area in 1982. Every building has five floors, and for this reason it is called Peoples Panchtala Colony. In order to address the pollution from the Peoples Panchtola Colony at Khalishpur in Khulna, the wastewater that is being discharged directly into the nearby open areas, would require proper treatment with regards to environmental conservation. Prior to the start of Nabolok EEHCO project which was funded by Water Aid, Bangladesh, mostly the

residential wastewaters including sewage were being disposed directly either into storm water drains or open areas without any treatment. Due to unaffordable cost of construction, most of the drains in the towns and cities are open as a result they are misused, sometimes serving as defecating sites for homes without adequate toilet facility. In consequence, self-purification capacity of receiving water bodies is overloaded and it causes surface and ground water pollution, impacting directly to the health of community, reducing the value of environment.

Residential wastewater even sewage and Wastes were dumped beside their residence and near about the premises of their residence because there were not any sewerage systems or damping place (Figure 2). Thus foul odor were emitted which pollute the environment. Blockage of drainage systems is occurred for wastewater overflow during rainy season. For that reason surface water bodies as well as groundwater was polluted. Moreover, wastes were spread of by scavenging birds and animals.

Figure 4: Waste and wastewater including sewage dumping practices before the DEWATS implementation.

DEWAT has created clean and aesthetic environment (Figure 3). The open drain which was a breeding ground for disease germs is now safe space for colony people. For the successful functioning of the system, a community managed operation and maintenance system has been designed. A full time sweeper from the local community has been employed to look after the operation and maintenance of the system.

Figure 5: After the DEWATS implementation.

The wastewater quality was found to be gradually improved. The value of wastewater quality parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Oil and Grease, pH, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Faecal Coliform, Temperature Nitrate and Phosphate were also found to be gradually decreased. So, it is a clear indication that the treated wastewater can be mixed with natural water bodies or used for irrigation purposes or reused for the community toilet flushing. The most importantly it improve the livelihood of this settlement.

Survey and data analysis:

Analysis is following the JMP indicators through FGD and observation. Access to proper sanitation facilities and wastewater discharge has been found alarming in the Hrishipara slum .In Hrishipara slum, almost 30% latrines are unhygienic (i.e. without water seal and venting system). Open defecation is still practiced by some children living in the slum. In this privately owned slum, the slum-owner is not interested to install sanitary latrines, while slum people are not permitted to construct latrines. Because of this, a very unhealthy situation is prevailing in the slum.

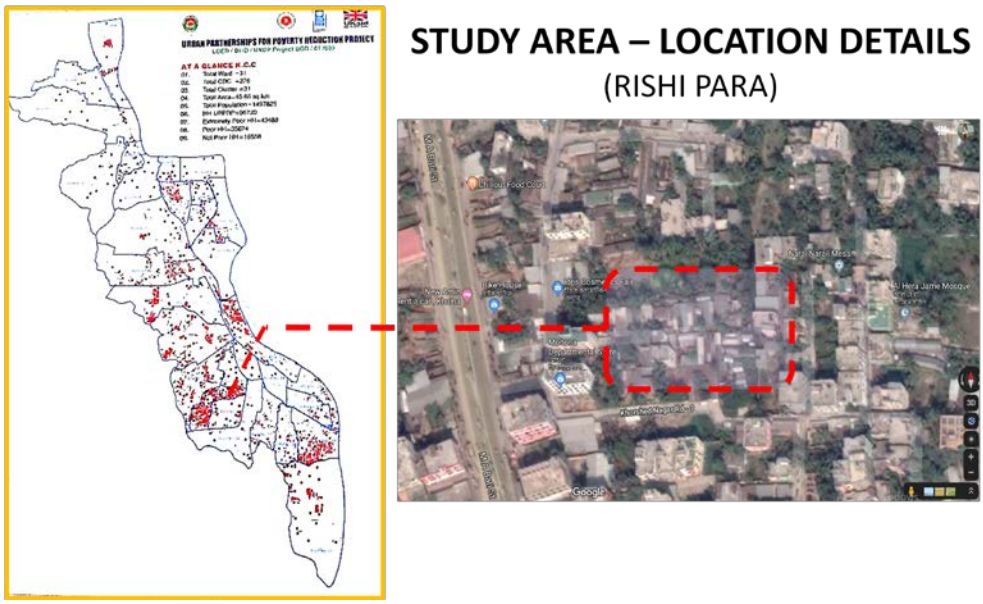


Figure 6: Study area

Table of existing sanitation condition based on JMP:

Indicator	condition
Improved sanitation facilities	Dry latrines
Improved sanitation facilities connected to sewers	No
Improved sanitation facilities connected to septic tanks	No
Improved pit latrines or other on-site improved facilities	Yes
Unimproved sanitation facilities	Few households
No sanitation facility (open defection)	No
Improved sanitation facilities which are shared (limited sanitation services)	Yes, not limited
Improved sanitation facilities which are not shared (basic sanitation services)	No
Sewer connections where wastes research treatment plants and are treated	No
On site sanitation facilities where wastes research treatment plants and are treated	No
On –site sanitation facilities where wastes are disposed of in situ	Yes
Safely managed sanitation services	No

The JMP now divides improved sanitation facilities into three categories: limited, basic and safely managed services. The population using improved facilities that are shared with other households will now be called limited rather than shared. Improved facilities that are not shared count as either basic or safely managed services, depending on how excreta are managed. Most of the slum households use limited sanitation facilities, few household use basic or safely managed services.

Fishbone diagram of wastewater problems of Hrishipara:

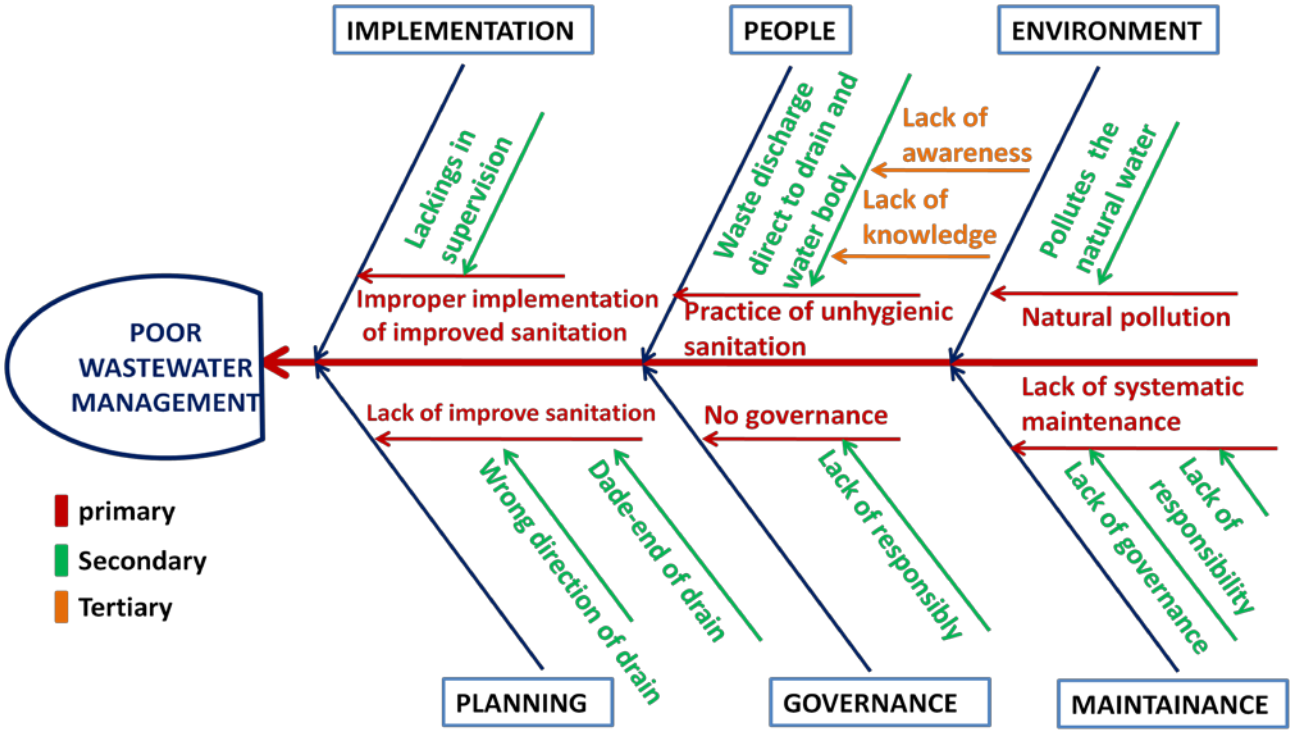


Figure 7: Fishbone diagram of wastewater problem

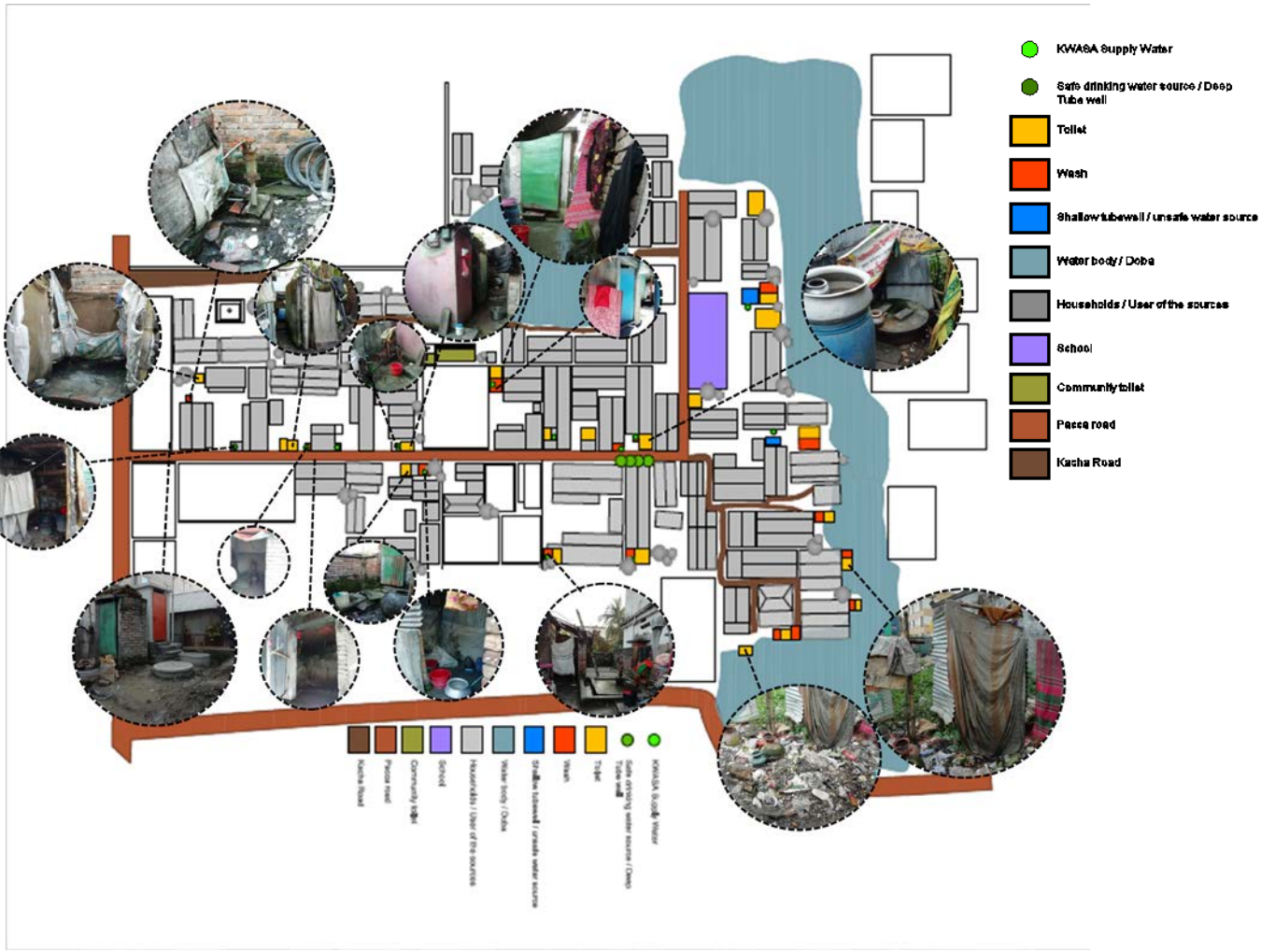
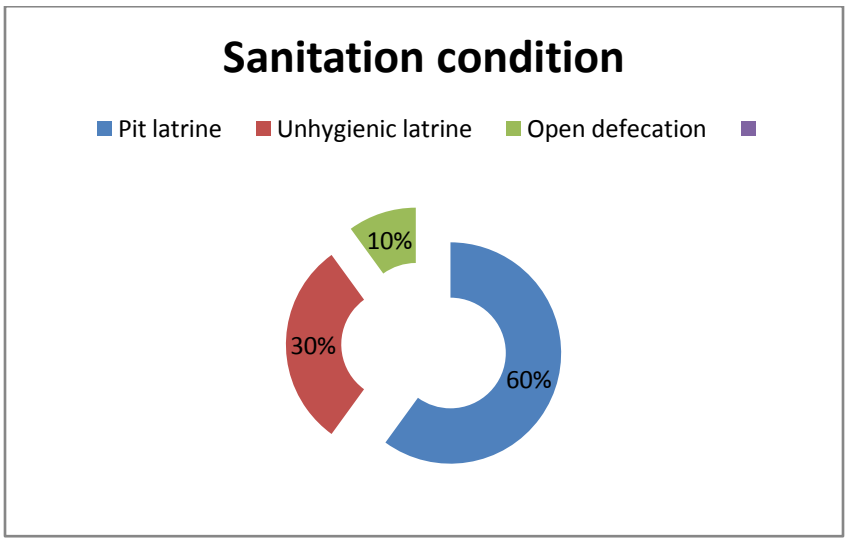


Figure 8:Hrishi para problem map (existing)

Figure 9: Condition of unhygienic sanitation and waste disposal of Hrishi para



Issues Associated with Existing Sanitation Facilities and waste water in Hrishipara:

The survey sought to establish whether respondents think there are problems associated with their sanitation facility. 80% of respondents reported at least one problem, with the most frequently mentioned problem being shared usage (58.5%) followed by smell (38.7%) and toilet not always available when needed (20.2%). This study observed that most of the latrines were open pits that smelled bad because they were very shallow or full; a few had visible breeding areas for flies. The mud floors in traditional pit latrines had dirty floors, preventing the water draining away in a hygienic sanitary way and providing a favorable breeding ground for flies. The participants in focus group discussions said that most of toilets were dirty and this caused health problems, such as intestinal worms, typhoid and diarrhoea, especially amongst children. They also complained about problems with open defecation practiced by people without toilets in their settlement. Similarly, owner occupiers reported the issue of open defecation when their pits fill up. In addition, they reported that people empty the toilets into the drainage channels and solid waste dumps at night. The tenants also complained about the pits, which fill quickly. So the waste water are being over flowed.

Constraints to Sustainable DWTS in Hrishipara:

Results from the survey showed that the most important constraints to install DWTS lack of money (68.2%), insufficient space (12.3%), difficult in obtaining permit (3%), and lack of information (0.2%). As far as toilet waste emptying and transport were concerned, only 40% of respondents reported emptying their pit latrines. Yet when a pit fills up, emptying is often the only sustainable option. Of the 15 cases where households emptied their pit latrines, 34% transported and rests are dump theis waste in backside water body. This shows that waste

emptying and transport services are almost non-existent in Hrishipara. It was found that lack of money was a major constraint of emptying.

Challenges to install DWTS in Hrishipara:

Regarding the challenges to install DWTS in Hrishipara, it was found that the high population density and the ensuing congestion of houses contribute to the lack of space for latrines. This leads to pits being dug close to houses, which weaken the foundations of already poorly constructed houses. Pit latrines with a slab represent improved sanitation in its most basic form, but once the pit is full it no longer provides this service; and the pit must either be covered over, and a new latrine constructed, or the existing pit get to be connected with the concentrated septic tank of DWTS plant. Hrishipara has no clear strategy for the emptying of pit latrines and only 15% of households empty sludge from their pits. Therefore, there is a risk of the full latrine overflowing, contaminating the environment with large quantities of excreta containing harmful pathogens and causing offensive smells and health issue.However, smell was not reported as a major problem. From the findings of this study, a possible explanation for this disparity could be that, a significant proportion of pit latrines in this informal settlements might be connect any how technologically to add them as a part of DWTS plant. Another problem that was noted in relation to full pits is the potential for the pollution of groundwater under or near pit latrines, particularly in areas with high water table , which is the case of most of informal settlements of Khulna. This is a serious problem because it affects the quality of drinking-water.

The situation might be improved if financial support from local and national governments was available. However, unlike other developing cities, there are no Non-Government Organizations (NGOs) working on sanitation issues in the informal settlements of Khulna. This is supported by the study conducted in Hrishipara where it was found that it is feasible to provide DWTS facilities with the help of Government and Non-Government Organizations.

Recommendation about implication of DWTS:

In developing countries, unimproved sanitation facilities are the prime cause of widespread environmental pollution by waste water and serious health problems, but improvements in these services show few health benefits unless they are coupled to improved hygiene behavior. On the basis of above analysis by overcoming theses constrains to solve these problems, DWTS may be a smart solution for now a days and future. And from the study it is clear that Hrishi para slum has potentiality to install the DWST plant to manage the wastewater. As the plant required space according to accommodate the components of the DWTS, so it can be placed beside the community toilet given by Nobolok which is the sharing toilet of this community. By using this community toile it can be assumed that the wrong practice of unhygienic sanitation can be reduced in a significant number. So it will help to improve their livelihood. If a large number of

people use that hygienic toilet then the wastewater of that toilet and household can be managed through DWTS.

- It is recommended to the special professionals dealing with decentralized wastewater management in Bangladesh for counseling the inhabitants of the settlement. It is necessary to provide adequate technical information and to build up capacity in adequate education and training formats for all stakeholders involved in decentralized wastewater management
- Habitants have to use improved toilet connected with septic tank.
- Have to stop use of the unhygienic open toilet and direct disposal of toilet and household waste to drain and water body by local government and policy.
- Have to clean the personal and sharing toilet's septic tank in a regular interval period and dispose the waste in the determined place not here and there.
- Maintaining over the total waste can be treated through decentralized wastewater treatment system.

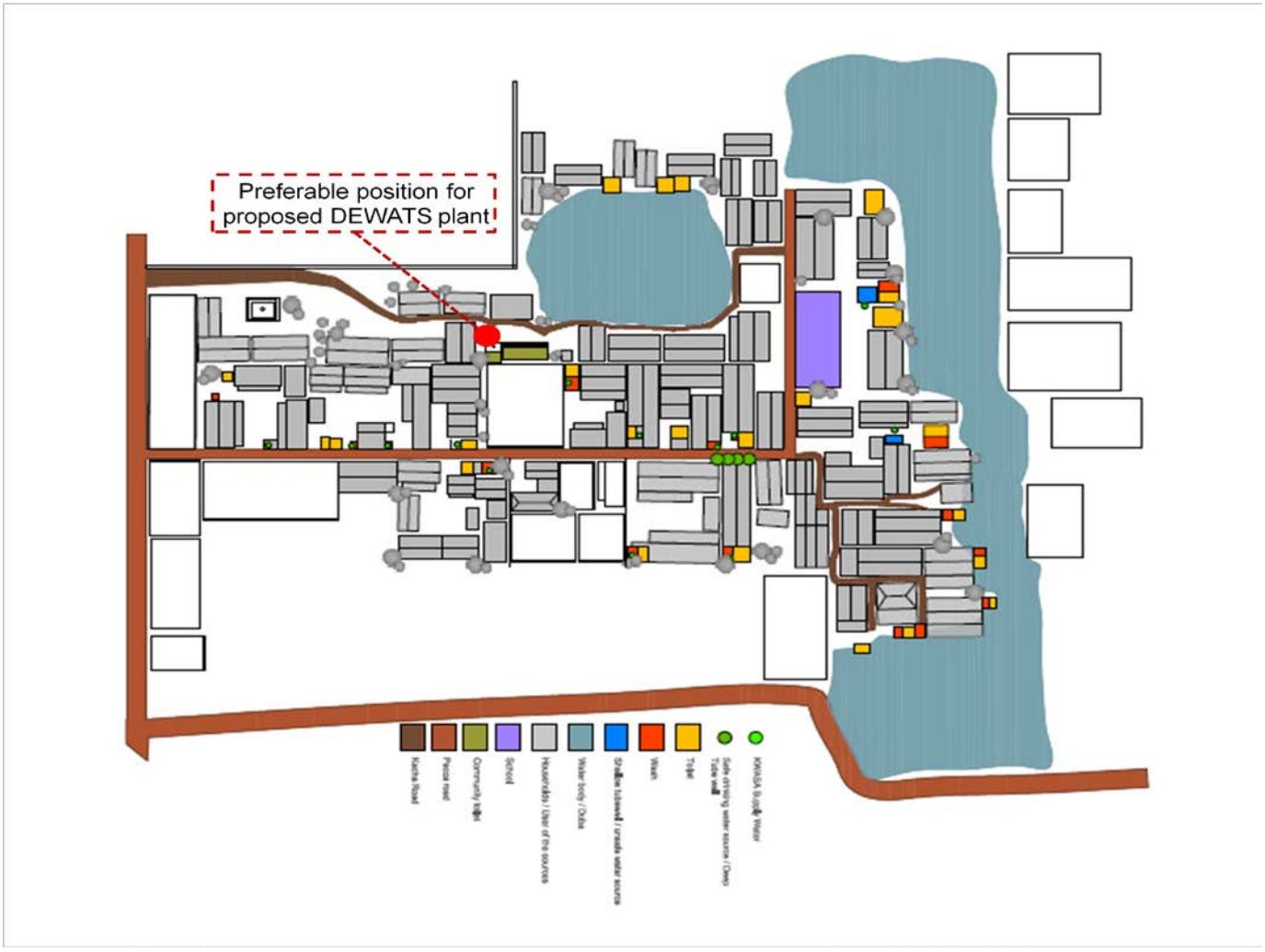


Figure 10: Proposed DEWATS for Hrishi para

Conclusion:

The aim of this study was to analyze challenges and the potentiality of DWTS in the informal settlement named Hrishipara and proposes DWTS technologies that match with the requirements of study settlements of Khulna. The study used a mixed method approach and this included transect walks, a household survey, focus groups discussions and key informant interviews. A good conceptual design of any wastewater wetland before it is being built the context should be the major concern.

To this end, this implies that dwellers of informal settlements are inclined over time to reject these traditional pit latrines for alternative low-cost more sustainable options, such as innovative decentralized wastewater treatment system and reuse and water serving sanitation technologies, because they can play a part in reduction of over exploitation of natural water sources, which continue to be scarce, as a result of population pressure in the country. DWTS technologies are appropriate in informal settlements because they occupy less space, do not require emptying by vacuum tankers, pre-treatment/composting, provides opportunity for nutrients re-cycling which is environmentally sustainable and, if well maintained, have minimal harmful effects. However, to be able to provide improved sanitation options for these communities, pilot projects are necessary so as to measure acceptability. Meanwhile, since the majority of residents do still depend on shared sanitation facilities to reduce the sanitary-related diseases, more emphasis has to be placed on hygiene education practices, focusing on proper use and cleanliness of the facilities.

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