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Research Paper

Wastewater Treatment and Management in Health Sector of Sri Lanka

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ABSTRACT

Hospitals are highly populated facilities that function 24 hours a day. They generate a large amount of wastewater through various sources which are very complex and hazardous. Furthermore, the emission of healthcare wastewater into the cities sewerage, rivers and groundwater pollute the entire system. Therefore, disposal of healthcare wastewater without adequate treatment can cause short and long-term ill-effects to the public's health. An onsite wastewater treatment would give a dual benefit of preventing the release of hazardous materials into other sources and bring the wastewater into the consumption cycle. At present, most countries utilize the treated wastewater to reduce the consumption of potable water. However, the literature review and preliminary studies revealed that wastewater management is poorly practised in the Sri Lankan healthcare sector. Therefore, this paper aimed to identify the extent of wastewater treatment, utilization and management in Sri Lankan state sector hospitals. The aim of the paper was achieved through a literature review and questionnaire survey. The required data were collected from nine state hospitals in Colombo. Findings of the study revealed that a high quality of wastewater treatment and efficient reuse of reclaimed water is a big challenge for the healthcare sector due to the complex nature of the wastewater process, higher cost of treatment and poor management. Moreover, it was found that currently wastewater generated from the state hospitals are discharged directly into the city's sewerage without any treatment. Finally, this paper discusses the current level of wastewater treatment, utilization and management in the state hospitals and identifies the critical barriers for the lack of poor practice of wastewater handling.

Keywords: Healthcare Sector, Reclaimed Water, Wastewater, Wastewater Management

INTRODUCTION

Water is a non-substitutable resource. Increased stress on water consumption in recent times has led to a need to ensure its availability for future generations (Savenije, 2002). The "Fit for purpose" approach should be adopted in water consumption than using potable water for all purposes (Kivaisi, 2001). Furthermore, the consumption of water, as well as the discharge of wastewater, has become a matter of great concern (Casani et al., 2005). Wastewater treatment can serve as a logical way to recycle water to the consumption cycle (Nasr and Yazdanbakhsh, 2008). As Hanjira et al. (2001) mention, wastewater treatment has reached the next level to shift its focus from treating wastewater for disposal to reusing as a resource.

In developing countries, the demand for water by a hospital is 400-1200 litre per bed per day (Chong and Jin, 2012; Gautam et al., 2007). According to Gadelle (Emmanuel et al., 2009), the consumption of water by hospitals far exceeds the minimum household consumption of an inhabitant per day. Moreover, these wastewaters are

hazardous to public health and ecological balance since it contains many kinds of pollutants such as radioactive substances, chemical, microorganisms and pharmaceuticals (Gautam et al., 2007; Sharpe, 2003). After consumption, the pharmaceuticals are excreted through the patent's urine to the hospital sewerage system (El-Gawad and Aly, 2011). Furthermore, many antibiotic-resistant bacteria and resistant gene carriers have been found in samples of water collected in areas around the hospital (Fuenetefria, 2011). This type of discharge can lead to pollution of the groundwater used for drinking purpose (Emmanuel et al., 2009). The contaminations of hospital wastewater with the city's water system can result in skin diseases or enteric illnesses and microorganism can cause diarrhoeas and cholera (Nasr and Yazdanbakhsh, 2008; Gautam et al., 2007). Moreover, Boillot and Panuiller (2007) state that hospital wastewater is capable of generating major environmental problem as they are 5 to 15 time more toxic than urban affluence. Therefore, wastewater generated by the healthcare sector has to be attended to very carefully as they are complex in the mixture (Boillot and Perrodin, 2008). Such hazardous healthcare wastewater should be pre-treated before discharge. Such practice of onsite treatment would prevent the cities' sewerage system and river (Gautam et al., 2007; Chong and Jin, 2012). Furthermore, reclaimed water can be used as an alternative resource for water scarcity. Kivaisi (2001) found that in most developing countries, there are very few wastewater treatment facilities. Also, the same author emphasizes this is mainly due to the high cost of treatment processes and lack of effective environmental pollution laws or law enforcement. Accordingly, this paper aims to identify the current practice of wastewater treatment, utilization and management in the Sri Lankan state healthcare sector and investigate the issues with the implementation of wastewater treatment, and utilization of the reclaimed water.

Wastewater Management

Wastewater is nothing, but it is the used water or liquid waste generated by the community. In other words, it is a semi-liquid that contains impurities or pollutants in the form of solid, liquid, gas or a combination of all that is harmful if disposed into the environment (Karia and Christian, 2006). According to Al-Bazi et al. (2008), generally the municipal wastewater can be separated into three components, namely black water (water containing faces), yellow water (water containing urine), and greywater (water from washing machines, shower, and kitchen sinks). Furthermore, as the authors mention black water is a major concern for health risks, yellow water contains a high amount of nitrogen and phosphorus that could be used as a source for fertilizer and greywater can be purified relatively easily and reused for various purposes. At the same time, it is estimated that today throughout the world, more than 5 million people (mostly children) die annually from illnesses caused by drinking poor quality water. Liquid wastes such as untreated sewage or industrial waste are the major sources of pollutants in developing countries.

Furthermore, it was found that municipal sewerage and industrial wastewater containing readily biodegradable organic matter, inorganic and organic chemicals, toxic substances and disease-causing agents are frequently discharged into aquatic environments (oceans, rivers, lakes, wetlands) without treatment (Kivaisi, 2001). The coastal areas suffer from water quality problem and one of the main reasons is wastewater discharge. This could be eliminated by good management of wastewater and stormwater management (National Research Council, 1993). According to Al-Anzil et al. (2011), the reuse of reclaimed wastewater in Kuwait has greatly reduced the amounts of

pollutants discharged into the sea. Volumes of wastewater discharged into the sea have been drastically reduced from about 65% in the year 2000 to about 30% in the year 2010. According to Abraham et al. (2011), the prevention of pollution of water sources and protection of public health by safeguarding water supplies against the spread of diseases, are the two fundamental reasons for treating wastewater. In 'Introduction to wastewater treatment' by Templetion and Butler (2011), the above reasons have been given as the traditional aim of wastewater treatment. Accordingly, the emerging trend is treating wastewater for recovery of energy, nutrients, water and other valuable resources from wastewater. Today indiscriminate usage of water, coupled with an ever-increasing demand has imposed a serious threat on the current supply and future availability of water (Chartres and Varma, 2010).

Water scarcity occurs when the water demand exceeds the available amount of water and when the poor quality of water limits water usability (Miller, 2013). As Stikker (Kivaisi, 2001) mentions in 1998, the number of people lacking access to safe drinking water mainly in developing countries will increase between two and three billion in the year 2000. However, the growing imbalance between demand and supply of potable water can be managed through recycling wastewater into the lifecycle (Hanjira et al., 2001). Moreover, treating and reusing wastewater is currently receiving attention as a reliable water source for agriculture and other industries (Akpor and Muchie, 2011). Furthermore, recycled wastewater can serve as a more dependable water source for human being since it is not affected by drought or climate changes. Reusing treated wastewater for purposes (flushing, gardening) that require lower quality of water allows increase the availability of potable water for activities that require high quality of water, such as for drinking. This practice will contribute to more sustainable resource utilization (Aoki and Memon, 2005).

Wastewater in Healthcare Sector

Hospital wastewater represents one of the most ubiquitous water sources in the total urban water cycles, where the generated effluents are usually loaded with domestic waste and hazardous healthcare waste (Chong and Jin, 2012). The amount of water consumption by hospitals per day varies from research to research. Emmanuel et al. (2009) state that, in developing countries, the average demand for water by hospitals is 500 litres per bed per day and as Chong and Jin (2012); Gautam et al. (2007) mention in their researches that the water demand per bed per day is 400-1200 litres. The water requirement for a bed per day in a hospital vary within the range of 400-1200 litres which far exceeds the minimum household consumption of 100 litres per inhabitant per day which gives rise to large volumes of wastewater (Emmanuel et al., 2009). Hospitals generate wastewater from different sources. Gazer (2009) categorizes the hospital wastewater as domestic and process wastewater depending on their source of generation. Furthermore, Gazer (2009) says 25% -35% of the wastewater generated in hospital is from domestic waste such as sinks, showers, toilets/urinals. The process wastewater is 65%-75% which is generated through irrigation, heating ventilation and air-conditioning (HVAC), food service, sterile processing, medical vacuum, imaging, and analytical labs. Furthermore, the water usage in the healthcare sector can be categorized as water used for the core function which is the staff and patient usage and non-core functions such as facility usage.

Table 1. Core and non-core water usage in the healthcare sector (U.S. Department of Health and Human Services, 2012)

Core Functions	Staff and Patient Usage	Drinking, Fountains, Dietary, Dialysis services, Eyewash stations, Ice machines, Laboratory, Patient decontamination, Patient floors, Pharmacy, Surgery, Radiology, Toilets, Washrooms, Showers.
Non-core Functions	Facility Usage	Air-conditioning, Boilers, Dishwashing, Laundry, Autoclaves, Medical equipment, Outdoor irrigation systems, Fire suppression, Sprinkler system, Vacuum pumps, Water system, Flushing, Water-cooled air compressors.

Research done by Ravikant et al. (2002) illustrates that the daily hospital water requirement of patients, their relatives, hospital activity and residential area is 354,000 litres, irrigation of gardens and green belt consumption is 146,000 litres. The total wastewater generation out of this water consumption is 339,000 litres. Jolibois and Guerbet (2006) stated that hospital wastewater includes a great variety of micro-contaminants that are chemicals, heavy metals, disinfectants and specific detergents resulting from diagnosis, laboratory, research activities and drug excretion by patients. Further, the physicochemical and microbiological characterization studies performed on hospital effluents in several industrialized countries have highlighted the presence of pathogenic multi drug-resistant microorganisms, radioisotopes, organ halogens and drug residues (Leprat, 1998; Erlandsson and Matsson, 1978; Emmanuel et al., 2009). The major microorganisms found in wastewater influents are viruses, bacteria, fungi, protozoa and helminths. Although various microorganisms in the water are considered to be critical factors in contributing to numerous waterborne outbreaks, they play many beneficial roles in wastewater treatment (Akpor and Muchie, 2011).

Traditionally, microorganisms are used in the secondary treatment of wastewater to remove dissolved organic matter (Akpor and Muchie, 2011). Hospital wastewater quality and management have become critical issues as they possess potential health risks and damage to the environment, which has taken a central place in the national health policies of many countries (El-Gawad and Aly, 2011). The disposal of untreated hospital wastewater which contains antibiotic-resistant bacteria is also a concern since it constitutes a health risk to the population (Fuentefriai et al., 2011). The risk level of wastewater varies depending on the content of the wastewater. If the characteristics of wastewater are not as per the accepted standards, then the wastewater is more hazardous. One of the main environmental problems caused by hospital effluents is their discharge in urban sewerage systems without preliminary treatment (Gautam et al., 2007). Hospital wastes could be dangerous to the ecological balance and public health. Furthermore, pathological, radioactive, chemical, infectious, and pharmaceutical wastes, if left untreated could lead to outbreaks of communicable diseases such as diarrhoea, cholera, skin diseases and enteric illness (Gautama et al., 2007). This can be eliminated by treating the wastewater specially generated in the healthcare sector. These facts emphasise that a pre-treatment is necessary for hospital wastewater to prevent the

hazard from being transferred to other water sources through cities sewerage. Furthermore, if the wastewater of the hospital could be reused then it would give a dual benefit.

Research Method

The questionnaire survey was selected as the most suitable research method for this study because the questionnaire is a well-established tool within social science research for acquiring information on participant's social characteristics, present and past behaviour, standards of behaviour or attitudes and their beliefs and reasons for action for the topic under investigation (Bulmer, 2004). As such, the questionnaire consists of both close-ended and open-ended questions. This study was conducted among the nine state hospitals in Colombo. One respondent from each hospital was selected depending on the person who has the knowledge and experience in wastewater treatment and management. The sample consists of one director, one medical superintend, two infection control nurses and five public health inspectors. Data collected through close-ended questions were analysed using a descriptive statistical analysis tool. Furthermore, the open-ended questions were structured through NVivo software and analysis was done using a descriptive statistical analysis tool. Figure 1 shows all the themes developed using NVivo to arrange the findings of the survey.

Data Analysis

Waste water management

The section consists of an analysis of data collected through the questionnaire survey conducted among the state hospitals and through personal observation. This section elaborates on the current wastewater management practice in the state hospitals. The barriers affecting proper wastewater treatment and reuse have been analysed in subsequent section.

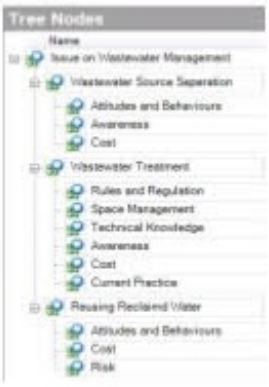

Fig. 1. Nodes of categorizations of response

Wastewater source separation

The current practice of wastewater disposal is satisfactory to the management of the hospital according to the empirical data. Moreover, to make a change or to introduce a new system in the government sector needs to undergo a long procedure. Furthermore, during the survey, it was revealed that lack of awareness of people regarding wastewater

source separation is one of the barriers. Further, it was revealed that the management, staffs, and the public have a lack of knowledge on the importance of source separation and its benefits. However, as found from the survey, the government hospitals function within the yearly budget allocated. Therefore, any additional financial requirements also should be fulfilled through this total budget allocated per year. Moreover, the parties believe initiating such practice of source separation requires larger refurbishment works which need significant investments. Figure 2 illustrates the barriers of wastewater source separation in the state hospital which were identified through the survey.

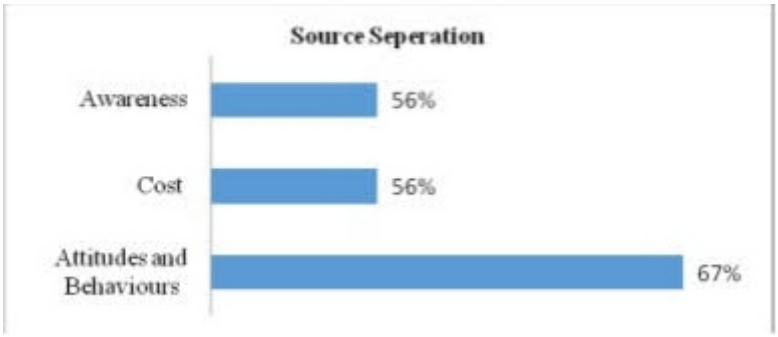

Fig. 2. Barriers in implementing source separation

Accordingly, the main barrier in the state hospitals is the attitudes and behaviour of people which has been pointed by 67% of the respondents. Besides, lack of awareness and high cost also influences up to 56% of hospitals to adopt the practice of managing the wastewater from the point of wastewater generation. Although, lack of awareness can be solved through properly educating, training and by giving awareness but to find an alternative for the high cost of starting a new practice is a challenge as stated by many respondents.

Wastewater treatment

As found from the survey, starting an onsite wastewater treatment requires a high initial cost for the plant, construction and staffing. Besides, maintaining such a plant requires high maintenance cost as well. In consideration of the government sector, all these have to be managed within the budget and this is the main reason why hospitals are not interested in implementing an onsite wastewater treatment plant. However, the hospitals currently fulfil the legal requirements regarding wastewater disposal.

This means that there is no strict regulation enforcing on the onsite wastewater treatment for the healthcare wastewater. Therefore, when there are no such legal requirements and the current practice satisfies the regulations of hospitals. Therefore, the hospitals are reluctant to implement wastewater treatment plant at present. The other issue of wastewater treatment is the space allocation for the treatment plant. As the sample was selected from the state hospitals in Colombo, most of the hospitals have limited space. A wastewater treatment plant requires a large area not only for the plant but to protect the neighbourhood from odour and infections. However, it was revealed to find such a large area from the hospitals situated in Colombo is not possible. Moreover, as discussed under (5.1.1) the management, staffs and public have a lack of awareness about the importance and the use of wastewater treatment. Moreover, it was found that lack of technical knowledge and satisfaction with the current practice are some barriers faced by the few state hospitals. Figure 3 summarizes the barriers to wastewater treatment in the state hospitals identified during the survey.

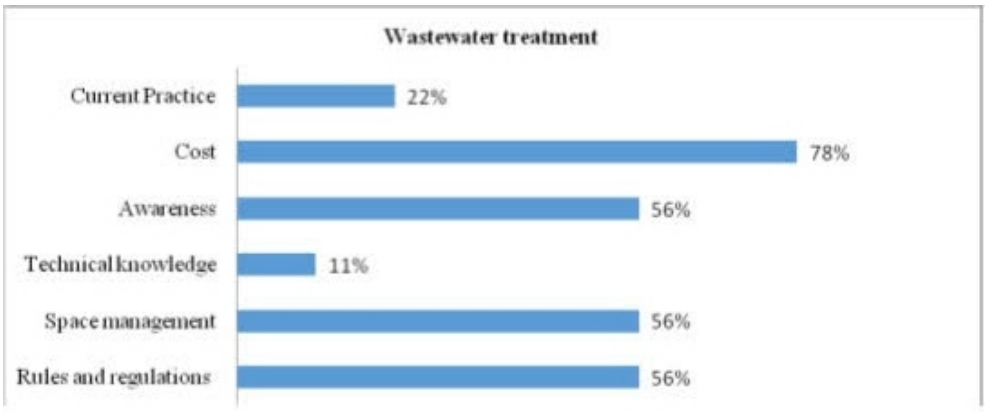

Fig. 3. Barriers in implementing wastewater treatment

As per the respondents' views, 78% of hospitals cannot bear the cost associated with the implementation and maintaining the wastewater plant. Besides, 56% of hospitals have issues of lack of awareness, inadequate space as well as lack of government rules and regulations. However, satisfaction with the current practice and lack of technical knowledge is not a barrier for most state hospitals. Therefore, the hospitals are willing to change from their current disposal method but they do not have enough financial support for such changes.

Reusing reclaimed water

According to the survey, wastewater in the healthcare sector needs a high level of treatment. If wastewater is not adequately treated, it is risky to reuse. Meanwhile, a higher level of treatment requires costly high technology. Furthermore, the use of reclaimed water is not popular especially in the healthcare sector at present. In hospitals, patients' safety from infections is very important. Therefore, the management is reluctant to use the reclaimed water because it may have the risk of spreading disease to patients and staffs. According to the survey findings, Figure 4 illustrates the barriers to using reclaimed water in state hospitals.

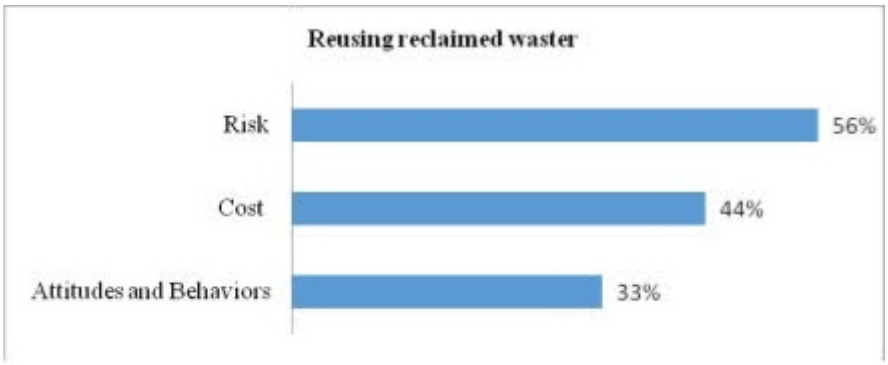

Fig. 4. Barriers in using reclaimed water

As per the respondents' views, 56% of hospitals are reluctant to start the practice of wastewater treatment because of fear of reusing inadequately treated wastewater, 44% of respondents have the opinion that the cost of reclaimed water will be higher than the potable water, and only 33% have agreed that there is an attitude

behaviour problem. In summary, the survey revealed that there are barriers exist in wastewater management at all levels. However, the attitudes and behaviour of people towards source separation, financial barriers to implement and maintain wastewater treatment and risk of reusing reclaimed hospital wastewater are the most important problems in the processes of wastewater source separation, treatment and reuse.

Critical Barriers/Issues in Initial Stage of Improving Wastewater Management System

According to the survey, there are few barriers in all the levels of the wastewater management system. Figure 5 summarizes all the issues or barriers related to wastewater management such as wastewater source separation, wastewater treatment and reusing the reclaimed water. According to Figure 5, the cost is the common hindrance in all the levels and it is a highly influencing factor. The respondents say, during the implementation of source separation, cost involves the construction work and metering equipment. In the wastewater treatment process, cost involves construction, buying plant and equipment, staffing, and maintenance cost. Further, while reusing reclaimed water, significant cost spends for buying the advanced techniques to treat the healthcare wastewater system. Such advanced treatment methods are more expensive as stated by the respondents. Therefore, using reclaimed water is not an economic alternative for potable water. However, this is one of the areas that need to be carried out in future research studies.

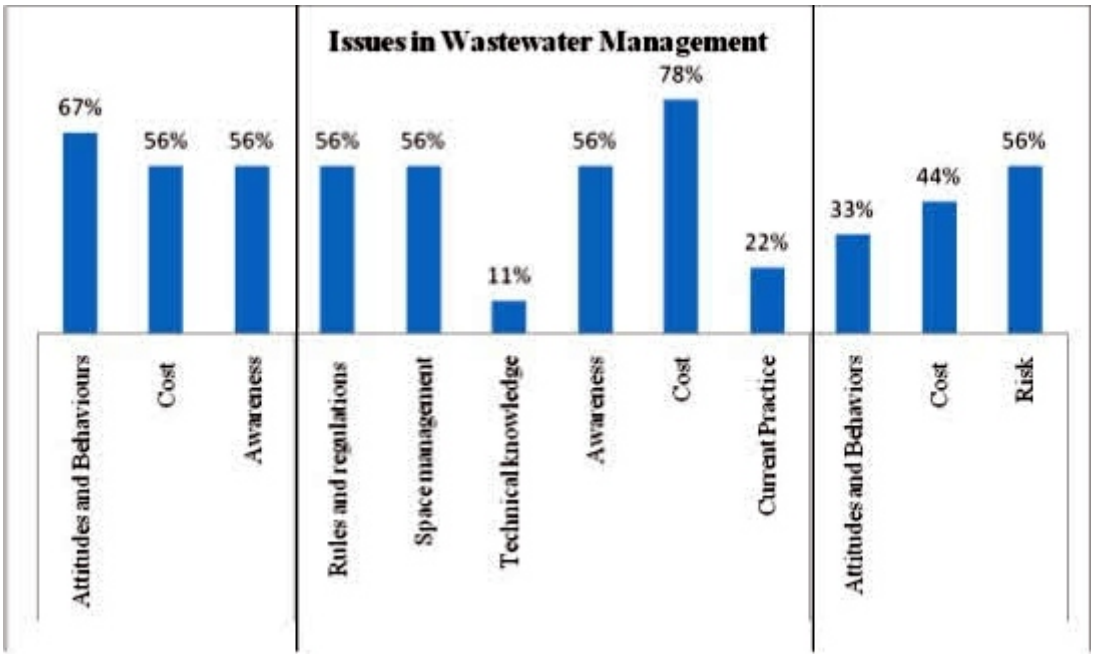

Fig. 5. Summary of barriers/issues in the wastewater management process

Another critical issue is difficult to find a solution to the risk of reusing wastewater. The risk is in-cooperated with reusing reclaimed water cannot be eliminated without knowing the exact quality of reclaimed water. As found from the survey, wastewater treatment is not practised in the Sri Lankan government sector hospitals. However, the research suggests at least pre-treatment should be implemented before discharge as a pioneering step.

Furthermore, collecting funds for such a big scale is difficult and challenging at present. The problems like attitudes and behaviour, lack awareness and satisfaction with current practice could be eliminated by training, education and giving awareness. Since it requires interest and manpower rather than financial support. However, it is the government responsibility to look into feasible approaches to overcome the issue of high cost. In future, once the system is well accepted and with additional funds, source separation and reusing reclaimed water can be in-cooperated into the system making it a well comprehend scheme.

Conclusions

Effective wastewater management should start at the source of generation. This is to separate the wastewater at the source of generation, treat the wastewater and reuse it as much as possible. The level of wastewater treatment, utilization and management are very poor in the Sri Lankan State sector hospitals. According to the findings, the wastewater generated in the state healthcare sector is discharged into the cities sewerage without even a pre-treatment. However, it was found that many hospitals do not release the wastewater directly into environmental water sources. This practice is sufficient to fulfil the existing government regulations on wastewater disposal. However, the literature emphasises that prior treatment is required for healthcare wastewater before disposal. Furthermore, the issues such as poor attitudes and behaviour on source separation, higher initial and maintenance cost of the wastewater treatment plant and the risk of reusing reclaiming water are the very common barriers encounter in the state hospitals. Besides, lack of awareness among the management and public, lack of rules and regulation on wastewater, and lack of space to implement wastewater plant are some other significant issues resulting in such poor wastewater management practices. However, the respondents say, at present, there are no direct hazards to the natural water sources by discharging wastewater from hospitals since the wastewater is discharged into the city's sewerage line. Moreover, the respondents identified the importance and benefits of implementing wastewater treatment in the hospital premises though some barriers exist.

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