Strategies for Effective Water Management in Health Care (HC) Sector in Sri Lanka

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Abstract: Healthcare (HC) facilities were the most water consumed industry in 2012 averaging almost 50 gallons per square foot per year. Water is an essential element for HC facilities and it is consumed for the purposes of medical treatments, washing surgical equipment, kitchen/dish washing, laundry, cooling and heating, domestic and restroom, etc. to create a soothing environment for patients, staff and facilities. The water and wastewater services cost is identified to rise above the consumer price index level in HC facilities. However, HC finds restrictions when applying water saving measures as maintaining quality of water is a crucial factor. Further, it has been identified that, there is no single approach or solution for dealing with water quality issues within HC. Thus, the aim of this research was to investigate the current water management practices of HC facilities and propose suitable strategies to save water in Sri Lanka. Hence, this study reports on current water management practices of four case studies i.e. private sector HC facilities. The required data was collected through site observations and semi-structured interviews conducted among professionals who are responsible for water management in selected facilities. The findings revealed that the current water management practices are basically focused on technical measures and the human measures have been relatively neglected. The study proposed several water management strategies which will address both technical and human measures. Application of these strategies will enable the management of HC facilities to minimize the drawbacks of their current water management practices and reduce the water consumption of their facilities by a considerable amount.

Keywords: Water management; Healthcare; Strategies

1.0 Introduction

Water is essential for human life while being an indispensable resource for the economy, and also plays a fundamental role in the climate regulation cycle (Euro stat, 2012). Although two third of the earth's surface is occupied by water, the percentage of fresh water that can be consumed by human beings is less than 1%. According to the second United Nation world water development report (as cited in National Cleaner Production Centre [NCPC], 2012) if the present water consumption pattern continues, two thirds of the world's population will face water stress by 2025. Amongst the different facility types, Healthcare (HC) sector is among a community's largest consumers of water (United States Department of Energy, 2011). A study of Practice Green Health organization (2002) indicated that HC typically use 25% of their water for domestic use (Sink, showers and toilets) and 75% for non-domestic / process use (Boilers, chillers, laundry, kitchen etc). In addition, most HC facilities have been built with little consideration to conservation or wise use of water. Inefficient usage of water, lack of monitoring for water usage, inadequate plan for water supply system and poor system maintenance can be identified as some

major problems that HC facilities face in relation to water consumption. However, establishing a comprehensive water management program in HC facilities will enable sustainable water consumption (U.S Department of Energy, 2011). This will help to reduce the operational cost contributing to mitigate the water crisis. Therefore professionals who involve in water management need to draw into innovative ideas to meet both of those concepts in order to achieve effective and efficient water consumption. Accordingly, the aim of this paper is to study the current water management strategies practiced in Sri Lankan HC sector.

2.0 Literature

2.1 Water management in HC Facilities

Water management can be described as the process of planning, monitoring and controlling of facility water use and water quality in order to obtain an optimum use from available water. According to the National Cleaner Production Centre [NCPC] of Sri Lanka (2012), water management concept has major two aspects as water conservation and water efficiency. Water efficiency focuses on achieving the same result with the minimum amount of water usage while water conservation directs towards reducing the wastage of water. Effective water management in the Commercial, Industrial and Institutional (CII) sector can have a tremendous impact on overall water consumption and deliver a range of economic and environmental benefits (Cohen Cohen, Ortez & Pinkstaff, 2009). Amongst, HC systems consumes largest proportion of water ranging from per capita 40 gallons to 350 gallons per day depending on factors such as; geographical location, services provided, size, age, type of building, water use equipment and practices (United States Department of Energy [DOE], 2011). Further, New Hampshire Department of Environmental Services [NHDES] (2013) indicates that HC facilities with steam sterilizers, autoclaves, x-ray equipment, in-house laundries and kitchens can be significant water consumers, using as much as 30,000 gallons of water a day. As common to any facility, HC comprises of domestic water uses of drinking, washing and personal hygiene. Moreover, there are number of unique water-using activities in HC facilities such as; vacuum pump systems, medical air and compressor equipment, sterilizers and central sterile operations, laboratory hood scrubbers, X-ray equipment and film developers, water-treatment systems for kidney dialysis and laboratory water, therapeutic baths and treatments. Since large hospitals employ several water use functions, effective and efficient water usage is a major requirement in medical facilities. However, there is a major constrain when applying water saving measures to HC facilities as it needs to maintain quality of water. Because there is a higher risk for water to get contaminated and people to get infected by water (Angelbeck, Ortolano, Canonica, & Cervia, 2006). Therefore management need to be aware when implementing water management strategies.

2.2 Common Water Management Strategies

There is a wide variety of common water management strategies available for all facility types such as;

1. Water Management Plan (WMP): A water management plan (WMP) is an essential tool to achieve an effective and sustainable outcome in relation to water efficiency (DEH, 2006). It comprise of facility surveys, water use monitoring, determining performance targets, identifying saving options, engaging building users and allocating resources (AFED, 2010).

2. Water Use Monitoring and Education: routinely monitoring facility water use through existing water meters and metering. This enables to quickly find and fix leaks or other water wastages (EPA, 2012).
3. Water Management in Different Functional Areas;

Table 1: Water management strategies for different functional areas

Functional areas	Water management strategies
Washrooms and toilets	Install dual or variable flush systems for water closets and commodes (AFED, 2010). Improve the flush systems with modern low volume cisterns and flush systems (Environment Agency of UK, 2007). Install manual flush or sensor operated flush for urinals (AFED, 2010). Improve the faucets and showers with high efficiency models with aerators (Cohen, Ortez, & Pinkstaff, 2009). Install sensor operated faucets to avoid the water wastage when opening and closing a manual faucet (Texas Water Development Board, 2011).
Commercial kitchens	Install a pre-rinse spray valve in order to reduce water and chemical consumption of dishwashers in commercial kitchens recirculation strategy is enabled in the hot water boiler system
Laundries	Wash full loads only by adjusting laundry schedules or washing clothes only when it is necessary (AFED, 2010). Change the existing laundry methods / chemicals into new methods / chemicals that require fewer wash and rinse steps (WUCB, 1999). Install a rinse water reclamation system to reuse discharged rinse water or Use batch washers that use less water since they reuse rinse water for the first rinse (WUCB, 1999).
Mechanical systems	Install water meters on the makeup water and blow down line of cooling tower systems and monitor Continuously treat cooling tower water to prevent forming of scaling or use softened makeup water to control bleeding rate (Weimar & Browning, 2010). Use treated air handler condensate water, grey water or rain water as cooling tower makeup water. Install an automatic blow down control for boilers
Pools, spas and ponds	Using rain water or raw water for water ponds in the hospital premises Shutting down or removing unnecessary fountains or waterfalls Using the pool water for several cycles Reusing drain water from pools, spas and ponds for different purposes such as landscaping. (AFED, 2010).
Outdoor Water Use	Watering plants early in the morning in order to minimize the evaporation of water. Making sure sprinklers have been adjusted accurately towards landscape plants. Adjusting sprinklers and other water delivery devices to concentrate water at the root area of plants. Refraining from watering when it's windy or raining. Using a hose with an attached nozzle or spray head with an automatic shutoff option to avoid water waste.

	Planting low water use trees, shrubs and ground covers instead of high water use turf grass (EPA, 2012).

2.3 Specific Water Management Strategies for HC facilities

HC facilities should consider unique water management strategies to manage water as 4 – 15% of the water consumption is used for medical proceedures. The medical equipment used run throughout the day and night and use large quantities of water (Cohen et al., 2009). Some of the strategies could be used to minimize the consumption of water and presented in the Table 2;

Table 2: water management strategies for medical equipment

Equipment	Water management strategies
Medical Equipment with Single Pass Cooling	Equipment such as; ice machines, film processing X-ray machines, degreasers, hydraulic equipment, condensers, air compressors and vacuum pumps etc. use the single pass cooling system which is inefficient. Strategies such as; 1) shut off water of single passing cooling systems when they are not in use 2) Install automatic valves to stop water flow when equipment is not in use. E.g. Use temperature control valves 3) Improve existing single pass cooling water film processing equipment with closed loop cooling systems 4) Replace original liquid ring vacuum pumps 5) Use new technological machines that do not consume water for cooling or film processing (North Carolina Department of Environment and Natural Resources, 2002).
Distil Water Plant	Use of closed loop system or cooled by passing through a chilled water coil (Acmas Technocracy Limited, 2010).
Steam Sterilizers	Retrofitting steam sterilizer with a water saving device to monitor the drain water temperature and applies cold water only when necessary. Collect the steam released by the steam trap of the large steam sterilizers and send it back to the boiler through the condensate return line to the boiler NHDES, 2013).

3.0 Methodology

A case study approach was adopted in which site observation and semi structured interview techniques were chosen as the quickest and most cost effective way of studying the current set of practices in HC facilities in managing the water consumption. Accordingly, four case studies were conducted in four leading private hospitals in Sri Lanka which comprised of all the medical services (such as; medical operations, dental, X-ray, Magnetic Resonance Imaging / Computed Tomography (MRI/CT) scan, dialysis medical laboratories and biomedical tests etc.) and building services (such as; central water supply system, central air conditioning system, fire protection system, sanitary facilities, laundry and kitchen etc.). Further to the observation of the current water

management practice, Maintenance / chief engineer and the bio-medical engineer were interviewed in order to gain insights in the current water management practices of the selected HC facility. Findings of the four case studies are analyzed through cross case analysis in relation to the water management and conservation techniques. Thus, Table 3 provides the details of the selected four HC facilities;

Table 3: Specification of the selected case studies

	HC facility "A"	HC facility "B"	HC facility "C"	HC facility "D"
Year of Construction	2002	2003	1986	2008
No of Beds	200	165	375	80
Average patients bed occupancy	170 to 180 beds	130 to 140 beds	240 to 260 beds	60 to 70 beds
Main water source	city water[1]; bottled water for drinking; Tube well for landscaping	city water; bottled water for drinking; Tube well for landscaping	city water; water purification plant used for drinking	city water; bottled water for drinking;
city water demand per month	11000 – 12000 m^3	9500 – 11500 m^3	16500 – 18000 m^3	3900 – 4500 m^3
central air conditioning system -	03 chillers and 03 cooling towers	03 chillers and 03 cooling towers	03 chillers and 03 cooling towers	03 chillers and 03 cooling towers
Steam system	3 industrial boilers - capacity 1500 liters	3 industrial boilers - capacity 1500 liters	No central boiler system; Mini boilers	No central boiler system; Mini boilers

In addition to this common features such as; washing machines, steam driers, steam irons were used in laundry while dishwashers, pre-rinse spray valve, hot water boilers, faucets were used in kitchen. Further, all four hospital were found to be equipped with sprinklers, hose reels and pillar hydrants with a comprehensive plumbing system. In terms of the medical services sterilizers, dialysis unit with RO water plant, distil water plant, bio-chemistry analyzer, chemical disposing process, X-ray machines and MRI / CAT scanners etc. were observed as major water consuming equipment in the selected HC facilities.

4.0 Findings

This section presents the cross case analysis results of the four HC facilities.

4.1 Use of alternative water sources: City water supplied by the National Water Supply and Drainage Board (NWSDB) was found to be the major water source consumed by the HC facilities. City water is produced up to the drinking water standard through the purification plants. However, it was found that providing safe drinking water for the occupants is a major responsibility of a HC facility, thereby HC facilities A, B and C use bottled water purchased from a reputed supplier while HC facility C produces drinkable

[1] from the national water supply of Sri Lanka

water from their own purification plant. Further, it was found that HC facilities A and B uses tube well for purposes such as; flushing needs of washrooms and landscaping.

4.2 Water Consumption of HC facilities: All the four HC facilities were significantly consuming high amount of water for daily operation of the facility. Even though the HC facilities comprised of various alternative water sources, HC facilities measure their water consumption of the city water. Further, the amount of water required varied upon factors such as; average occupancy, medical activities taken place, building support activities to function the HC facility and climate conditions etc. However, it was noted that all the HC facility required high amount of water as below;

Table 4: Water consumption of HC facilities

Hospital	Monthly city water demand (m^3)	Average monthly occupancy (patient beds)	Specific consumption (m^3/patient/month)
A	11000 – 12000	5250	2.1 – 2.3
B	6500 – 7300	4050	1.6 – 1.8
C	16500 – 18000	7500	2.2 – 2.4
D	3900 – 4500	1950	2.0 – 2.3

Accordingly, HC facility B has lesser specific consumption of city water when comparing with other HC facility. The main reason behind that is HC facility B uses raw water that is taken from a tube well for flushing needs of washrooms and for landscaping. However, other HC facilities still use city water for flushing in washrooms. HC facility A also uses raw water for its gardening, but still city water is used for all the internal water uses. Hence, a significant difference cannot be seen among Hospital A, C and D. Therefore, Hospital B was found to be managing the water sources effectively.

4.3 Water Management Plan of HC facilities: None of the HC facilities adopted a comprehensive water management plan and almost similar types of plans are implemented except for few additional strategies.General outline of a comprehensive water management plan had been derived in the water efficiency guide of Australian Government Department of Environment and Heritage [DEH] (2006) in the areas of; initial plan, baseline data and performance targets, water saving measures, management performance and performance reporting. Accordingly the HC facilities water management plan was analyzed with respective to the above water management plan;

- *Initial plan:* Purpose, scope, policy, principles, goals and objectives were identified as the contents of the initial plan. Neither HC facilities consisted of a proper initial plan a separate policy and a set of principles for water management. However, it was found that the responsible officials of the HC facilities were concerned about efficient usage of water, but they did not establish exact goals and objectives towards water conservation. In addition to the water conservation the quality of water is also a major concern of a proper water management plan. In respective to the quality of water it was found that the HC facility A tends to monitor the city water every three months and maintain the quality while the rest of the facility fails to do.

- *Baseline data and performance targets:* This stage of the plan requires the availability of data and set baselines to plan the water management. The responsible department has to maintain the data of water system, equipment required for different end users. It was identified that none of the HC facilities established a baseline or performance

target. Yet the respective officials were knowledgeable to maintain an appropriate level of water performance depending on their knowledge and experience. All the HC facilities monitor and maintain data records of their overall water consumption data. Additionally Hospital C and D monitor the water consumption of few sub-systems as well. Therefore, responsible officials had identified a performance range for those sub-systems, but not an exact performance target. Further, HC facility A and B monitor only the water demand for main supply lines only.

- *Water saving measures*: According to the stated water management plan a well-structured technical water efficiency measures and conservation measures should be stated in the current plan. In the selected HC facilities few water efficiency and conservation measures were included in existing plans focusing on the preventive maintenance aspect to prevent water wastages from leakages. Monitoring the water consumption levels and inspecting the plumbing systems were also identified as preventive maintenance activities. As a conservation measure, HC facility A has a plan to guide the staffs towards effective use of utilities through inter departmental awareness programmes and it was not identified among other HC facilities. In terms of the technical water efficiency measures none of the HC facilities had a systematic procedures stated in the plan. However, necessary technical efficiency measures are applied in HC facilities to increase the water usage by the responsible officials but not going through a specific plan.

- *Management performance:* management action plans, assessment criteria and a risk assessment procedure are included in the management performance. Especially water assessments and risk assessments are required to identify the technical / behavioural efficiency measure and conservation measures in a systematic way. Thus, it was found that neither such plans nor procedures were available with the selected HC facilities to monitor the performance of water management.

Performance reporting: engineering department of HC facility A keeps records of daily city water consumption and these are reviewed by a top management personnel at the management review meeting once a month. In similar way, maintenance department of HC facility B, C and D have to report the monthly utility consumption to the audit committee and monthly water consumption data are reviewed at the annual audit meetings. Considerably good performance reporting procedures are practiced in selected hospitals and it has been a major requirement of their water management plans.

4.4 Water use monitoring and leak detection: In HC facility D Cooling tower makeup water lines, water supply to the kitchen and laundry have been sub-metered. Water consumptions at those functional levels are monitored separately in addition to the main city water supply. A similar procedure was found in the HC facility C where the cooling tower makeup line and water supply to the purification plant have been sub-metered and was daily monitored. Yet the rest of the other HC facilities A and B only monitor the usage of the city water supply line. Further, leak detection techniques were found and presented in the Table 5;

Table 5: Current water management strategies practiced in terms of water use monitoring

Strategies	HC facilities			
	A	B	C	D
Maintains daily records of water use and they are reviewed to ensure the consistency of water use	Yes	Yes	Yes	Yes
Implement preventive maintenance to make sure possible leakages are prevented	Yes	Yes	Yes	Yes

Perform water assessments or audits at least once four years	No	No	No	No
Make leak reporting as a responsibility of staff of the hospital facility	Yes	Yes	Yes	Yes

According to the Table 5 all the HC facilities practice most of the major strategies towards water leak detection. Yet they do not conduct water assessments or audits, most probably as a result of lack of expertise knowledge and lack of time. If water assessment were conducted, strengths and weaknesses of existing systems and procedures could be identified.

4.5 Education and training: The following strategies were cross checked in terms of the education and training aspect among the HC facilities and presented in the Table 6;

Table 6: Current water management strategies practiced in terms of education and training

Criteria	HC facilities			
	A	B	C	D
Communicate the existing water management programme to employees	Yes	No	No	No
Notice monthly water use figures to occupants so that they are informed about the progress	No	No	No	No
Create point of reminders to encourage occupants towards positive behaviours	No	No	No	Yes
Train/instruct maintenance and housekeeping staff to ensure efficient use of water at work	Yes	Yes	Yes	Yes
Provide water efficiency tips to regular water consumers / consuming functions	Yes	Yes	Yes	Yes

Train/instruct maintenance and housekeeping staff to ensure efficient use of water at work and provide water efficiency tips to regular water consumers / consuming functions were found to be practiced by all the HC facilities and rest of the strategies were not adopted. This reveals the approaches of selected HC facilities on user education and awareness is at a basic stage.

4.6 Water Management in Different Functional Areas;

4.6.1 Washrooms and Toilets: HC facility C used flush valves and cisterns and HC facility D has a cistern based flushing system. However, the main purpose of these flush valve systems is to facilitate frequent flushing within shorter time period. A significant water saving is not obtained with this system when comparing with cistern system. Unlike cisterns, the major weakness of flush valves is that water is released at high pressure thus, tend to waste large amount of water. Neither hospital had dual flush / variable flush systems for Water closets which are a technical weakness identified during the investigation. As a result, there is a wastage since a similar amount of water is flushed for both solids and liquids.

Urinals were installed in washrooms situated in common areas of all the selected HC facilities. Urinals in HC A and C had motion sensor operated flushing systems while HC B and D had manual flushing for urinals. Either sensor operated flushing system or manual flushing system similar water savings were obtained. Because unlike timing flush

controllers, urinals are flushed only after every usage and unnecessary flushes are avoided.

Considering about faucets in washrooms, they had been improved with motion sensors in common area washrooms in HC A and C. Good efficiency has been established there since sensor operated faucets avoid the water wastage when opening and closing a manual faucet. Further, faucets in washrooms of HC C and D are water efficient ones with faucet aerators that reduce the water flow rate without affecting the functional requirement. Showers are installed in resident patient washrooms and no specific technical improvement were found since they are not used frequently.

4.6.2 Kitchens: All the HC facilities comprised of dishwashers which enable to save large amount of water. However, more water savings could be obtained if the staffs operate the dishwashers with full loads. Pre-rinse spray valves were installed which enhance the water efficiency in the kitchen. According to the AFED (2010) pre rinsing dishes with the use of spray valve results in substantial water savings of the dishwasher. Furthermore, pre-rinse spray valves were available in the kitchens of the hospitals with a hand held trigger which helps the user to efficiently control the water flow.

4.6.3 Laundries: All HC facilities were equipped with in house laundry facility with similar equipment. Yet HC D's non-infected clothes and linen are out-sourced to wash. It could be considered as a good strategy to control the HC facilities water consumption. Washing machines were identified as the major consumer of water in the laundry. Mainly HC A, B and C had reduced the number of washing / rinse steps by using low soap chemicals while HC D conducts several wash and rinse steps that result in higher water consumption. In HC B, hot water is generated in the washing machine and washed with hot water which is an effective strategy for disinfection other than washing for several occasions. Installing a rinse water reclamation system is another good strategy which stores rinse water and reuses that as wash water for the next cycle. But this strategy is not practiced in hospital laundries because there is a risk of transferring infections from previous washing cycle to corresponding cycle, if rinse water is reused. Further the effectiveness of the washing machines can be improved by operating it with full loads and the staffs in HC facilities tend to wash clothes with full loads since used clothes and linen are regularly collected.

4.6.4 Pools, Spas and Ponds: Only HC A and B comprised of ponds and following strategies were found;

Table 7: Current water management strategies practiced in terms of pools, spas and ponds

Criteria	HC A	HC B
Supply line / makeup water line has been sub-metered	No	No
Rain water / Raw water / recycled water is used for water ponds	Yes	Yes
Use pond water for few cycles by a proper cleaning and filtering system	Yes	No
Reusing drain water from ponds for landscaping or gardening	No	No
Fountains and waterfalls have been avoided / switched off	No	No

Raw water is used by both hospitals for water ponds which is a good strategy. It is clear that Hospital A has a better strategy to reuse the pond water for few occasions after a filtering process. Both drain water from water ponds are left to drain lines, occasionally used for landscaping. This cannot be identified as a good strategy, because it is possible to use drain water for landscaping since it is not infected.

4.6.5 Mechanical Systems:

- *HVAC system:* cooling towers are the major water consuming part of the HVAC systems. Cooling tower water is continuously treated in all the HC to prevent scaling and it has resulted in saving considerable amount of water as blow down procedure is not required. As stated monitoring the cooling tower makeup water demand is practiced only in HC C and D while HC A and B has not even metered cooling tower makeup. Therefore, Hospital C and D have been able to easily find out defects of cooling towers and their plumbing systems. Further, HC D, regulate the HVAC through a Building Management System (BMS), thus, unnecessary cooling towers are switched off or cooling tower fan speed is controlled effectively. As a result HC D obtains savings in both energy and water.

- *Boilers / Steam systems:* Steam generated in the central boilers of HC A and B is used in laundry and sterilizers in the Central Sterile Supply Department (CSSD). It improves the efficiency of laundry and sterile function, but other hospitals use self-steam generating steam irons and sterilizers. It is difficult to distinguish between central boiler and self-steam systems, since water consumptions are not measured properly in the HC facilities. Taking the condensate return back to the central boiler was identified as a major water efficiency measure for the boiler. That technical feature was found in both central boilers of HC A and B. boiler blow down is performed by the boiler operator depending on a blow down schedules which is a proper strategy too. But the blow down process can be further improved through an automatic blow down valve, which blow down the boiler depending on the hardness level of water.

- *Fire protection systems: no specific water management strategies were identified.*

Medical Equipment and Processes: Medical processes and equipment were almost similar in every selected hospital except for few differences. When comparing those strategies with the current recognized strategies in the world, current level of performace are considerably good. For example; x-ray machines operate with newer dry imaging technology that does not use water for film processing. Magnetic Resonance Imaging / Computed Tomography (MRI / CT) scanners are cooled by rotating chilled water through a heat exchanger. However, a large amount of water is spent on other medical processes. Distil water plant is one such system that consumes a considerable amount of water. There a continuous water supply is sent through the plant to condensate the water vapour and it is left to drain even though that water is very much possible for recycling. Yet it is difficult to reuse or recycle that waste water since it is mixed with chemicals. Bio-chemistry analyzers in laboratories of HC also use distil water to wash the machine after every sample test in the analyzer which results in consumption of considerable amount of water. Sterilizers are another regularly used water consuming equipment. Sterilizers operate with steam, only smaller amount of water is released after each processing cycle. But discharged hot water is mixed with normal city water that mixture is directed to drain lines in HC facility A. Therefore, a considerable amount of water is wasted daily in HC A due to this single pass cooling method. But this method was not practiced in other HC facilities

and discharged water is directly released to drain lines. However as a management strategy, every HC facility should add cold water to discharge water only when necessary.

5.0 Conclusion

HC systems are among a community's largest consumers of water, a good management is required over their water consumption. Especially HC facilities have a greater responsibility for properly managing their own water consumption and contributing to minimize the crisis for water. However, the situation is similar in the Sri Lankan context as well, in fact it requires more from hospitals towards water conservation. Therefore, good management strategies should be implemented in HC facilities in Sri Lanka in order to ensure an effective and efficient usage of water. Hence, this research was conducted to investigate the water management strategies currently practiced in HC facilities. The study adopted case study case study approach and data collection was mainly done through site observations together with semi-structured interviews and data analysis was done through cross case analysis.

The findings of the case studies showed that the water management plans in the HC facilities were not comprehensively adopted, yet more focus was given to the technical aspect to conserve water without any planning. For example; different techniques were used at different functional areas such as; washrooms, kitchen, laundry, ponds and HVAC and boilers. Amongst, washrooms should incorporate dual flush systems and show point of reminders to guide the users how to operate it for better performance. Further, improvements were recommended in the existing fire protection system as it had no techniques to conserve water.

Monitoring water at different functional level was crucial, only HC facilities D and C incorporated it while the other A and B focused on monitoring the overall consumption of water. Therefore, hospitals need to implement a mechanism to monitor the water consumption at each functional level for example; sub-meter the makeup water lines to cooling towers and boilers and to monitor their water consumption daily. It could be helpful to troubleshoot the system as well as indirect motivation for the staffs to conserve water at duties.

In terms of the medical equipment it was found that all HC facilities had installed high tech instrument which allowed for savings of water. However, distil water plants of the HC facility need a technical improvement where the existing single pass cooling systems drain considerable amount of water just after cooling the condensation coil of the distil water plant. Therefore, that system need to be improved with a re-circulation mechanism or cool with chilled water produced in the central air conditioning plant.

By understanding the areas lacking in the current context with respect to water management, the professionals in to the HC industry can adopt necessary strategies in order to improve water savings which will reduce the operational cost of their HC facilities as well as help to contribute towards sustainability.

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