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A Study on Water Management Strategies Practiced in Healthcare Facilities: A Literature Review

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Abstract: Water management in facilities can be simply explained as consuming water effectively without obstructing the functions of the facility. Healthcare facilities are one of the major types of facilities which consume a huge amount of water for their daily operations. Therefore, water management in healthcare facilities should be given a special attention in order to reduce the operational cost of the facility while contributing to sustainable development of the country. Various strategies can be practiced for water management in healthcare facilities and the understanding on current water management practices is important to take necessary measures to improve the current practices. The aim of this research was to investigate the current water management practices of healthcare facilities. Hence, a comprehensive literature review was carried out to identify the water management practices of healthcare facilities. The identified strategies could be categorised in to two as general water management strategies and strategies which are specific to healthcare facilities. Application of these strategies enable the management of healthcare facilities to minimize the drawbacks of their current water management practices and reduce the water consumption of their facilities by a considerable amount.

Keywords: Healthcare Facilities, Strategies, Water Management

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). However, less than 3% of the globe's water is fresh, but 2.5% out of that is frozen. As a result humanity has had to rely on remaining 0.5% to fulfil its fresh water needs (World Business Council for Sustainable Development [WBCSD], 2005).

Agriculture is the main user of water by far and irrigated agriculture accounts for 70% of water withdrawals in the world (World Water Assessment Programme [WWAP], 2009). Industries are the second largest user of water after the agriculture and anyway the amount of water used varies widely from one type of industry to another (World Business Council for Sustainable Development [WBCSD], 2005).Therefore, domestic demand for pipe born water (city water) is improving significantly creating tight competition for city water between industries and domestic consumption.

Freshwater abstractions from public water supplies, irrigation, industrial processes and hydro power plants apply a major pressure on water resources with significant implications for issues of quantity and quality of water resources (Organization for Economic Co-operation and Development [OECD], 2005).

Healthcare sector is one of the industries that demands higher amount of water for their daily operations. And total water consumption of a hospital is divided among different functions of hospitals (US Department of Energy [DOE], 2011). Hospitals have to focus on water efficiency and conservation measures in order to ensure the sustainable use of water in the hospital (Smith, 2007). Accordingly, the aim of this paper is to investigate the water management strategies currently practiced in healthcare facilities in the world.

2.0 Water Management

Buildings can be classified into major five categories as residential, commercial, public, industrial and agricultural buildings and each type of building has different water

consumption levels (Bio Intelligent Service of European Commission [BIS], 2009). However, there are primary water use purposes such as toilets, showers, wash basins, kitchens, HVAC systems and landscaping that are common to any type of building (Arab Forum for Environment & Development [AFED], 2006). Although water consuming activities often remain similar, overall water consumption is greatly influenced by various factors such as building features/infrastructure, geographical location, appliances installed and human activities in the building (Groundfos Commercial Building Services [GCBS], 2012).

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. It further states that 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).

There are few major principles that should be considered when implementing a water management program. They can be explained briefly as follows;

- Basic principle of a good water management is to manage available water resources among the functions effectively satisfying the water demand and the water quality (DOE, 2011).
- Successful water management consider the technical side such as installing efficient fixtures and making maintenance modifications as well as the human side such as changing long standing behaviors and expectations (United States General Services Administration [GSA], 1999).
- According to GSA (1999) water management strategies can be categorized into major three general areas as;
    - Reducing losses
    - Reducing the overall amount of water used
    - Reusing water that would otherwise be discarded
- Water efficiency implementation at work starts with understanding a facility's water using processes and it is important to understand the facility water use and water use patterns before developing a water management plan (EPA, 2012).
- The management of the building must be committed to water management if they want to convince occupants that their actions make a positive difference (GSA, 1999).

3.0 Water Management in Healthcare Facilities

Healthcare facilities can be categorized into public buildings or commercial buildings. However, several core and non-core functions are performed in healthcare facilities and water is used in different amounts for all those functions. As common to any facility, domestic water uses such as drinking, washing and personal hygiene can be identified healthcare facilities as well. Moreover, there are number of unique water-using activities in healthcare 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

According to New Hampshire Department of Environmental Services [DES] (2013) these unique functions including laundry and kitchen account for a large percentage of total water consumption of healthcare facilities.

Since large hospitals employ several water use functions, water use effectively and efficiently is a major requirement in medical facilities and water management practices become more important. Hospitals and medical facilities have obtained significant operating cost and energy savings by instituting such water saving measures (North Carolina Department of Environment and Natural Resources [NCDENR], 2002).

But there is a major constrain when applying water saving measures to hospitals and it is that need for maintaining quality of water. In hospitals 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 careful much when implementing water reuse and recycling strategies. However there is no single approach or solution for dealing with water quality issues within healthcare facilities (Noonan & Garnys, 2014). Therefore, simply available quality water should be managed properly among functions that demand quality water while distributing low quality water among functions that do not demand quality water (Australian Government Department of the Environment and Heritage [DEH], 2006).

3.1 Common Water Management Strategies

There is a wide variety of common water management strategies available for facility managers to choose from, in relation to every use of water in a building. Some strategies simply alter the water use habits of building occupants while some others change the way of water systems are operated and maintained (GSA, 1999).

3.1.1 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). Facility water management plan should consider conducting facility surveys, water use monitoring, determining performance targets, identifying saving options, engaging building users and allocating resources (AFED, 2006). General outline of a WMP is given in table 1.

Table 1: General Outline of a WMP

Source: Water efficiency guide - Department of Environment and Heritage (2006)

Key areas	Details
Initial plan	▪ Purpose and scope ▪ Policy and principles ▪ Goals and objectives
Baseline data and performance targets	▪ Major water systems and equipment ▪ Water supply – metering and tariffs ▪ Consumption history ▪ End users and users ▪ Consumption drivers and KPIs ▪ Benchmarks and targets
Water saving measures	▪ Technical efficiency measures ▪ Behavioral measure ▪ Conservation measures
Management performance	▪ Management team / committee ▪ Management action plan ▪ Assessment criteria and scoring ▪ Risk assessment
Performance reporting	▪ Recipients ▪ Responsibility and accountabilities ▪ Scope, measures and targets ▪ Frequency

3.1.2 Water Use Monitoring and Education

Building operators can understand and manage facility water use by routinely monitoring facility water use through existing water meters and metering allows a facility to quickly find and fix leaks or other water wastages (EPA, 2012). This strategy has several functions to ensure an efficient water use in a facility and just installing meters at the required locations may not give a successful outcome. Those functions are;

- Choosing what to meter / sub-meter
- Installing meters
- Maintaining meters
- Take meter readings
- Recording metered data to track water use

Rectifying such leaks quite often provides the best return on investment of all water saving measures and it should be performed before going for any other water efficiency measures (DEH, 2006). Following methods can be used to detect the leaks and to avoid leaks;

1) Maintain records of water meters readings and pay close attention to variations (EPA, 2012).
2) Implement preventive maintenance to make sure the replacement of problematic items (DEH, 2006).
3) Perform a water assessment or audit of the facility at least once every four years (EPA, 2012).
4) Make water leak reporting as a responsibility of facility staff and encourage visitors as well (DEH, 2006).

User education is a cost-effective way to enhance a facility's water-efficiency efforts which can result in significant water savings (EPA, 2012). There are several measures that can be taken to educate employees and other building occupants on water savings;

1) Communicate the water management program of the facility to employees.
2) Notice monthly water use figures to building occupants so that are informed about the facility's progress.
3) Create point-of-use reminders to encourage positive behaviours.
4) Train and instruct relevant staffs to ensure proper implementation of any new or revised procedures involving water management.
5) Provide water efficiency tips to regular water consumers or consuming functions.

3.1.3 Water Management in Different Functional Areas

3.1.3.1 Washrooms and toilets

Every washrooms and toilets of buildings have at least some sanitary fixtures or equipment including water closets, urinals, faucets and showerheads etc... Following main water management strategies can be identified as commonly in relation to sanitary accessories.

1) Install dual or variable flush systems for water closets and commodes (AFED, 2006).
2) Improve the flush systems with modern low volume cisterns and flush systems (Environment Agency of UK, 2007).
3) Install manual flush or sensor operated flush for urinals (AFED, 2006).
4) Improve the faucets and showers with high efficiency models with aerators (Cohen, Ortez, & Pinkstaff, 2009).
5) Install sensor operated faucets to avoid the water wastage when opening and closing a manual faucet (Texas Water Development Board, 2011).

3.1.3.2 Commercial kitchens

Several other commercial or institutional sectors including hospitals, offices, schools, and hotels also have substantial kitchen water use that accounts for as much as 10% to 15% of the facility's total water use (EPA, 2012).

Hot water boilers supply hot water to different equipments and accessories of the kitchen such as faucets, pre-rinse spray valve and dishwasher and conservation mainly should be established at the hot water using equipment and accessories (Fisher-Nickel Incorporated [FNI], 2010). Further continuous recirculation system is water efficient where hot water is circulated through the system and unused water is returned back to the heater.

Install a pre-rinse spray valve in order to reduce water and chemical consumption of dishwashers in commercial kitchens. Pre rinsing dishes with the use of high-pressure nozzles with a hand-held trigger can result in substantial water savings of the dishwasher (AFED, 2006). Further it states that using a dishwasher whenever possible for washing dishes itself is far more water efficient than manual washing.

3.1.3.3 Laundries

Laundries are another high water use area especially for hospitals, hotels and commercial linen services (Water Use and Conservation Bureau [WUCB], 1999). There are both technical and behavioural measures to effectively manage the water consumption of commercial laundries;

1) Wash full loads only by adjusting laundry schedules or washing clothes only when it is necessary (AFED, 2006).
2) Change the existing laundry methods / chemicals into new methods / chemicals that require fewer wash and rinse steps (WUCB, 1999).
3) 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).

3.1.3.4 Mechanical systems

HVAC system, boilers and fire protection systems can be identified as mechanical systems that consume water for their operations.

Cooling towers are the major consumer of water of a HVAC system which usually account for up to 30-40% of a commercial or public building's water use (Chandrathilaka & Fernando, 2011). As the major consumer of water, the building HVAC system should be an obvious target for water conservation efforts where significant water savings can be obtained

(Weimar & Browning, 2010). Measures that can be taken to ensure a proper management of water in the HVAC system as follows;

1) Install water meters on the makeup water and blow down line of cooling tower systems and monitor (Weimar & Browning, 2010).
2) Continuously treat cooling tower water to prevent forming of scaling or use softened makeup water to control bleeding rate (Weimar & Browning, 2010).
3) Use treated air handler condensate water, grey water or rain water as cooling tower makeup water.

Water consumption rates of boiler systems differs depending upon the size of the system, the amount of steam used and the amount of condensate return (WUCB, 1999). There are few major water efficiency and conservation measures that can be applied to boilers;

1) Take condensate water return to the boiler and modify the system if this option is not available with the system.
2) Install an automatic controller to turn off the unit when steam is not in use or not required.
3) Install an automatic blow down control for boilers to better manage the boiler makeup water requirement.

Fire hydrant system and sprinkler system can be considered as water using fire protection systems. As major water conservation strategy, responsible personnel should maintain a proper procedure for the immediate detection of leakages and fix them. In addition to that rain water or raw water can be used to feed the fire protection systems instead of using pipe born water.

3.1.3.5 Pools, spas and ponds

Properly managing evaporation, leakages, presence of a fountain or waterfall and maintenance requirements will result in considerable water savings of pools, spas and ponds. Several major strategies to manage water consumption can be identified as follows;

- Sub-metering the water supply / make up line especially for the pools and spas.
- Using rain water or raw water for water ponds in the hospital premises.
- Taking immediate steps to the leakages of pools, spas or ponds.
- Shutting down or removing unnecessary fountains or waterfalls that causes for aeration lose and significant amount of vaporization.
- Using the pool water for several cycles by cleaning the water through a proper filtering system.
- Reusing drain water from pools, spas and ponds for different purposes such as landscaping.

3.1.4 Rain Water Harvesting, Waste Water Reuse and Recycling

Gray water discharged from bathroom sinks, showers and clothes washing machines is possible to reuse and recycle for some other purposes (GSA, 1999). Before reusing grey water, it requires a treatment including biological trickle filters, clarifier, self-cleaning filtration, UV filter disinfection and chemical treatment via a water monitoring system (DEH, 2006). Such treated grey water can be used for flushing in toilets, cooling tower makeup, floor or toilet cleaning and gardening (AFED, 2006).

Further some amount of overall water consumption may potentially be replaced by rainwater in commercial buildings. Systematically treated rain water can also be used for above mentioned water use functions.

3.1.5 Outdoor Water Use

If the facility maintains any landscaping, then exterior water use management should be an important part of the overall water management programme (WUCB, 1999). Landscape water use is largely dependent upon climate, plant type, and an irrigation system's efficiency (EPA, 2012). Therefore those factors should be concerned when effectively managing landscaping water use.

Following strategies and guidelines on efficient landscape irrigation can provide significant and immediate water savings (WUCB, 1999);

1) Watering plants early in the morning in order to minimize the evaporation of water.
2) Making sure sprinklers have been adjusted accurately towards landscape plants.
3) Adjusting sprinklers and other water delivery devices to concentrate water at the root area of plants.
4) Refraining from watering when it's windy or raining.

5) Watering deeply and less frequently instead of lightly every day.
6) Using a hose with an attached nozzle or spray head with an automatic shutoff option to avoid water waste.

Following maintenance, retrofit, and replacement options can provide additional landscape water savings (WUCB, 1999);

1) Planting low water use trees, shrubs and ground covers instead of high water use turf grass.
2) Ensuring that each type of plant material receives only the amount of water it needs.
3) Use water wise plants and a drip irrigation system instead of sprinklers for small turf (less than 10 feet wide) areas.
4) Separately monitor the volume of water applied to the landscape and carefully regulate the water delivered to each zone of the irrigation system.
5) Maintain a schedule for watering times and durations to feed plants with water only when required.
6) Inspect irrigation systems regularly and replace or repair broken sprinkler heads, broken or damaged components.

3.2 Specific Water Management Strategies for Hospitals

There are water saving technologies unique to medical facilities which should be considered for managing water, along with the water saving practices common to any facility (Arizona Department of Water Resources [ADWR], 2009). Between 4 – 15% of the water consumption of a hospital is used for medical equipment that is all vital to a well-functioning healthcare facility. Many of these machines run throughout the day and night and use large quantities of water (Cohen et al., 2009).

3.2.1 Medical Equipment with Single Pass Cooling

There are several medical equipments with single pass cooling systems as well which are inefficient. Such equipments are ice machines, film processing X-ray machines, degreasers, hydraulic equipment, condensers, air compressors and vacuum pumps (NCDENR, 2002). Water management strategies for such equipment are as follows;

1) Every time shut off water of single passing cooling systems when they are not in use (NCDENR, 2002).
2) Install automatic valves on single pass cooling water film processing or X-ray equipment to stop water flow when equipment is not in use. E.g. Use temperature control valves (NCDENR, 2002).
3) Improve existing single pass cooling water film processing equipment with closed loop cooling systems (Cohen et al., 2009)
4) Replace original liquid ring vacuum pumps which continuously discharge and replace fresh water, with water recirculation system.
5) Replace old technological equipment and machines with new technological machines that do not consume water for cooling or film processing.

3.2.2 Steam Sterilizers

Steam sterilizers are commonly used in laboratory or medical settings to disinfect containers, trays and other instruments. Steam is applied under pressure to destroy bacteria and other impurities in the sterilizer (DOE, 2011).

In order to save water in sterilizers mainly;

1) Retrofitting steam sterilizer with a water saving device which monitors the drain water temperature and applies cold water only when necessary (Cohen et al., 2009 & DOE, 2011).
2) 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 (East Bay Municipal Utility District [EBMUD], 2008).

3.2.3 Distil Water Plant

Distil water plants / distillers produce non-contaminant and non-infectious for laboratory usages (Acmas Technocracy Limited, 2010). A distil water plant has a process as in the chamber water boiled into water vapour and condensate the vapour in order to return back into liquid state. However a considerable amount of cool water is spent on condensation activity of the plant. If it is a single pass cooling system, need to change that to a closed loop system or cooled by passing through a chilled water coil (NCDENR, 2002).

4.0 Conclusion and Future Research Agenda

Healthcare facilities have a greater responsibility for properly managing their own water consumption and contributing to minimize the crisis for water. Therefore, water management strategies are required for healthcare facilities in order to ensure an effective and efficient usage of water. Water management strategies can be identified in few major categories as developing and acting on a water management plan, water use monitoring and education, water management in different functional areas, water use by mechanical equipment and water management in medical activities. The identified factors were categorised in to general water management strategies that can be applied to any type of facility and strategies which are specific to healthcare facilities.

According to Sri Lanka National Water Partnership [SLNWP] (2010), Sri Lanka is seemingly having adequate water resources, but there are seasonal and regional variations that lead to periodic water crises. Further, as per the Annual Report of Central Bank of Sri Lanka (2012), the demand for pipe born water has increased significantly in line with rapid expansion in commercial activities, industrial activities and urbanization. Hence, water management practices should be incorporated in such sectors in Sri Lanka as well.

Though adequate literature on water management practices could be found in global context, the available literature on water management in healthcare facilities is hardly found. Therefore, the article motivates an agenda for future research that advocates the evaluation of current water management practices of healthcare facilities in Sri Lanka.

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