SHORT COMMUNICATION

Water usage in a multi-speciality hospital and its effective management

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ABSTRACT

Context: Water is an important resource for hospitals. There are few studies about the quality, quantity and cost of water that is required for health care. **Aims:** To study the quality, quantity, cost and applications of water in a hospital. **Settings and Design:** Observational study. The study was done in a cancer hospital in eastern India. **Methods and Material:** Water generation and consumption patterns and costing were assessed after: Discussion with the engineers; analysis of documented records; observation of patient/visitor/staff behaviours; measurement of flow rates and metered readings; Individual water consumption surveys. **Statistical Analysis Used:** None. **Results:** The total filtered reverse osmosis (RO) water used by the hospital per day was 200,000 L. This equated to 1093 L/patient/day. The volume of filtered reversed osmosis water consumed showed that the total water usage for drinking was 1%, water usage for hand-washing was 18%, water usage for showering was 6%, kitchen water consumption was 2%, housekeeping activities usage was 4%, central sterile supply department usage was 4%, heating, ventilation, and air conditioning systems usage was 36%, hot water consumption was 5% and toilet flush usage was 24%. Cost was Rs. 1119/- for 10,000 liters of RO water and about Rs. 31/- for 10,000 liters of raw water. **Conclusions:** The economics of hospital water both in terms of consumption and cost is a valuable source of information for hospital planners, administrators and hospital engineers.

Key words: Conservation, health economics, hospital water, quality monitoring, reverse osmosis

Key Messages:
- Water is a precious resource. Wastage needs to be minimized
- It is important for hospitals to monitor its water usage
- Safe and adequate water is essential for effective hospital infection control and monitoring its microbiological quality is of paramount importance.

INTRODUCTION

Water is a vital resource for health-care activities. Data from 54 low resource low- and middle-income countries in the six World Health Organization regions (located in Africa, Americas, South-East Asia, Europe, Eastern Mediterranean and Western Pacific) showed 38% of health-care facilities did not have an improved water source(s), 19% did not have improved sanitation and 35% did not have water and soap for hand-washing.[1] Improved water source uses uniform definitions for safe water sources promoted by The United Nations Children's Emergency Fund. These include the following: Piped, public tap, standpipe, tubewell/borehole, protected dug well, protected spring, rainwater. The improved water source should ideally be within 500 m of the facility.[1]

Access this article online

Quick Response Code:

Website: www.jacmjournal.org

DOI: 10.4103/0972-1282.194956

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How to cite this article: Collett S, Samarin I, Bhalchandra R, Soundaranayagam JR, Garai S, Chandy M, Bhattacharya S. Water usage in a multi-speciality hospital and its effective management. J Acad Clin Microbiol 2016;18:135-7.

MATERIALS AND METHODS

Study design

The current study was conducted in an 183-bed cancer hospital in Eastern India, with the following objectives:

a. Water audit regarding consumption for various activities and quality
b. Estimation of the cost of hospital water
c. Developing water management recommendations.

Water generation and consumption patterns and their costing were assessed after:

- Discussion with the engineers
- Analysis of documented records
- Observation of patient/visitor/staff behaviours
- Measurement of flow rates
- Metered readings
- Individual water consumption surveys.

The total dissolved solids (TDSs) of the hospital reverse osmosis (RO) water is measured by a digital conductivity meter, the free chlorine by a digital chlorine meter and microbiology by the membrane filtration technique (Millipore) and quantitative culture on MacConkey agar (HiMedia).[2,3]

RESULTS

There are two main sources for our hospital water – two deep borewells to source the groundwater – and government water supply.

The raw water analysis of our hospital showed that the total hardness (as calcium carbonate) of the raw water to be 362 mg/L (desirable <300 mg/L), iron to be 2.54 mg/L (desirable <0.3 mg/L), TDS to be 835.7 mg/L (desirable <500 mg/L) and total coliforms to be 23 most probable number (MPN)/100 mL and faecal coliforms (3.6 MPN/100 mL).

However, the TDS of the hospital RO water is maintained at <100 ppm, the free chlorine between 0.2 and 0.5 ppm and microbiology adhered to the following standards: Zero coliforms and *Pseudomonas* per 250 mL of water, total aerobic colony count of <2000 CFU/mL of water.[2,3]

The total filtered water used by the hospital per day was 200,000 L. This equated to about 1093 L/patient/day (200,000 L/day divided by 183 patients). The total water used for drinking was 2048 L/day (1%), for hand-washing (including surgical hand scrubbing) 36,987 L/day (18%), for showering 11,948 L/day (6%), kitchen water consumption 4525 L/day (2%), housekeeping activities used 7361 L/day (4%), central sterile supply department (CSSD) 7246 L/day (4%), heating, ventilation, and air conditioning (HVAC) systems 72,000 L/day (36%), hot water consumption 10,000 L/day (5%) and toilet flush usage 47,885 L/day (24%) [Figure 1]. This calculation amounted to a total monthly water cost of Rs. 682,911 ($10,506) [Table 1]. The cost of water was highly sensitive to the cost of electricity with an estimated 66.6% increase in water cost if the cost of electricity in India was raised to the equivalent of that in Brazil and an estimated 22.2% rise in cost if the cost of electricity was equated to that in Russia. The rainwater harvesting potential for the hospital was calculated to be 4,409,120 L for the period from July to October (the rainy season for the region).

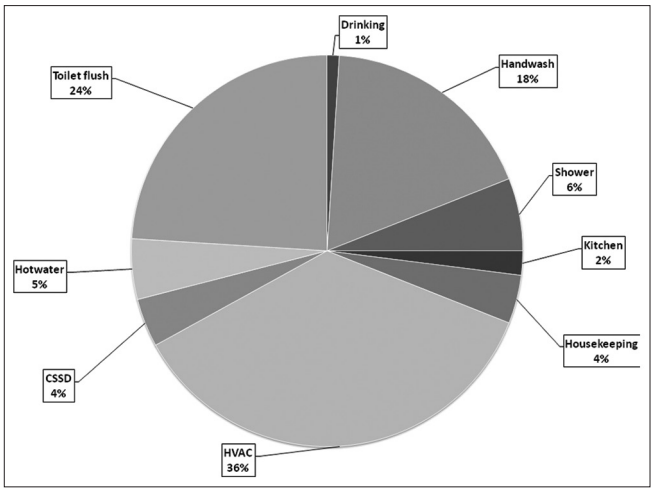

Figure 1: Water used in Tata Medical Center, Kolkata, West Bengal, India

Table 1: Monthly cost of hospital water in Tata Medical Center, Kolkata, India

Item	Raw Water [Rs (USD)]	RO Water [Rs (USD)]	Total [Rs (USD)]
Depreciation	0 (0)	89 011 (1369)	89 011 (1369)
Staff	0 (0)	56 000 (862)	56 000 (862)
Chemicals and Consumables	0 (0)	91 000 (1400)	91 000 (1400)
Electricity	15 900 (245)	388 500 (5977)	404 400 (6222)
RO Plant Maintenance	0 (0)	37 500 (577)	37 500 (577)
Government Water Supply	2 500 (38.5)	2 500 (38.5)	5 000 (77)
Total monthly Cost	18 400 (283)	664 511 (10223)	682 911 (10506)
Cost per 10 000 Liters	31 (0.48)	1 119 (17.22)	-

Rs: Indian Rupees; USD=United States Dollars; 1 USD: 65 Indian Rupees; RO: Reverse Osmosis

DISCUSSION

According to the 'Emergency water supply planning guide for hospitals and health care facilities' of the Centers for Disease Control and Prevention and American Water

Works Association 'health care facilities need to develop an Emergency Water Supply Plan to prepare for interruption of normal water supply.[4] Water supply interruption in health-care settings could result in serious compromise of hand-washing and hygiene, drinking, food preparation and hygiene, flushing toilets and bathing patients, laundry and other services provided by central services (e.g., cleaning and sterilisation of surgical instruments), reprocessing of medical equipment (e.g., endoscopes, surgical instruments and accessories), patient care (e.g., haemodialysis, hemofiltration, extracorporeal membrane oxygenation, hydrotherapy), fire suppression sprinkler systems, water-cooled medical gas and suction compressors (a safety issue for patients on ventilation), HVAC and decontamination.[4] Every health care establishment must have a "Water Use Audit plan" which should include (a) water usage under normal operating conditions, (b) identification of essential functions and minimum water needs, (c) identification of emergency water conservation measures and (d) identification of emergency water supply options, (e) development of emergency water restriction plan.[4]

Raw water analysis of our hospital showed high total hardness, high iron content, very high TDS and a significant number of total coliforms and faecal coliforms. These properties of high hardness, high iron load, high TDS and the presence of coliforms including faecal coliforms made the raw water unsuitable for applications such as drinking, cooking, hand-washing, bathing, housekeeping, air conditioning, instrument cleaning in CSSD, hot water generation. For all these applications, RO water is used in our hospital. The raw water is used only for specific applications, such as gardening and fire safety purposes.

The infection prevention and control activities (washing, housekeeping) and engineering controls dependent on water (air conditioning system) would be severely crippled in the absence of good quality water. In one US study, the water consumption per patient bed was 548,128 L/year and expenditure per thousand gallons was $4.64 (for 3785 L).[5] According to the Bureau of Indian Standards for hospitals exceeding 100 beds, the average consumption of water is 450 L/head/day (equating to 164,250 L of water/head/year).[6] In the case of our hospital, the total water consumption per bed was 405,555 L/bed/year (200,000 L/day for 183 beds). This is significantly more than the estimated water consumption for Indian hospitals. This excess water consumption could be due to central air conditioning of our hospital. According to one report published by the California Urban Water Conservation Council HVAC (heating ventilation air-conditioning)consumes maximum water (48%) in a typical commercial building.[7] According to another report, water cost saving opportunities in building HVAC systems include (a) identification and correction of system leaks, (b) using air handler condensate for cooling tower makeup and (c) ensuring closed system water usage.[8] In a Massachusetts study, the percentage of unaccounted water was found to be 9%, HVAC used was 23% of the water and sanitary use was 42%.[9] We intend to use the current analysis for future water management strategies. This may lead to less consumption of water, less waste and ultimately less cost.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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