The Turkish Journal of Occupational / Environmental Medicine and Safety

2017; Volume 2, Issue 1(3):1-7 Web: http://www.turjoem.com ISSN : 2149-471

SUSTAINABLE WATER AND WASTEWATER MANAGEMENT IN HOSPITALS

Ahmet ALTIN [1], Süreyya ALTIN [2]

[1] İzmir Demokrasi University, Faculty of Engineering, İzmir, Turkey

[2] Bülent Ecevit University, Department of Environmental Engineering, Zonguldak, Turkey

Corresponding Author:
Ahmet Altın, PhD
Engineering Faculty
İzmir Demokrasi University
Üçkuyular, 35140 İzmir, Turkey
Tel: + 232 260 1003
Fax: + 232 260 1004
e-mail: a.altin@idu.edu.tr

ABSTRACT

Hospitals are institutions that require high quantities of water in a certain quality and hygiene without interruption. However, in settlements where water supply is difficult and water quality is low, sufficient quality and quantity of water supplying has become an important cost item for hospitals. Besides, there are many macro and micro pollutants in the structure of the hospital wastewater. The negative effects of these pollutants on aquatic and terrestrial ecosystems are quite high. For this reason, today, in the framework of the concept of sustainability, it has become compulsory to establish and operate integrated water and wastewater management systems in hospitals. In this study, the activities causing water consumption in hospitals and the units with high water consumption were defined, the amount and quality of water required for these activities and units were determined, the alternatives that could be used in obtaining sufficient water were evaluated and strategies for reducing water consumption were put forward. In addition, the characteristics and quantities of wastewater from different units in hospitals are summarized, examples of these wastewater reuse applications are presented, and finally, appropriate treatment alternatives that can be used for the treatment of hospital wastewater have been defined.

Keywords: Hospitals, Water management, Wastewater management, Sustainability

INTRODUCTION

Water is an indispensable part of our lives. However, available freshwater resources are fairly scarce and not evenly distributed across the earth. The earth is under the influence of climate change from the 20th century onwards. The most important consequences of climate change are the uneven distribution of precipitation across the earth and the cases of drought observed in many parts of the world. Thanks to industrialization urban populations have grown and their living standards have increasingly improved all over the world and, as such, the matter of meeting the water of requirements of settlements has become an important issue. The human development report, prepared by the United Nations Development Program (UNDP), suggests that the global use of water has almost grown twice as much the population increase rate during the last century (1). The settlements situated in the areas of water scarcity have to make huge investments to facilitate a sufficient amount and quality of water transfer from distant areas. Moreover, operation and maintenance of the facilities thus established (especially for energy purposes) also adds to the mounting costs. For this reason, the concept of sustainable water management has been introduced for urban areas. In this respect, priority is given to such main strategies as the minimization of water consumption, adoption of water saving and recycling technologies.

Hospitals are listed among the biggest water consumers in cities (2). The quality and availability of water in hospitals are of critical importance for both the patient's health and the daily operations of hospitals (3). For this reason, and considering its potential economic contributions, the implementation of sustainable water management in hospitals has become more or less obligatory. For instance, the costs of water supply and wastewater treatment in Bostonian hospitals nearly accounts for 22% of the total service cost (4). That being said, a sustainable water management can be achieved with the development of integrated water and wastewater management strategies.

The present identifies the activities involving water consumption in hospitals and offers propositions as to how economically and conveniently supply the required water quality for such activities. Moreover, the general properties of the wastewater produced by various hospital units are also identified and the applicable wastewater treatment methods assessed and the potential reutilization of such water in various different operations presented.

Water Management in Hospitals

Water is of crucial importance in hospitals in terms of health and hygiene. Hospitals require a significant amount of water to be used on a daily basis for various different purposes depending on the nature of operations being implemented (2). According to a study conducted by the Victorian Government Department of Health (Health.Vic), Australia, the activities that require the most water consumption in hospitals are listed as follows (5):

- Washing (such as washbasins, taps, showers etc.)
- Sanitation (used for water closets and toilet flush tanks)
- Kitchens and cafeterias (for preparation of foods and beverages)
- Processing (cleaning, sterilization, washing, heating, cooling, water filtration and softening)
- Irrigation (for ornament gardens and grass)

The amount of water used for such activities varies between 20 and 40% in washing activities, 15 and 40% in processing activities and 5 and 25% in kitchen activities (6). On the other hand, the daily water consumption in 7 different 138 to 550 bed capacity hospitals in Boston, USA (accommodating 5100 to 11600 inpatients annually) varies approximately between 156 m^3 and 697 m^3. The distribution of water consumption in such hospitals in accordance with respective activities is presented in Figure 1 below.

As can be seen in Figure 1, cleaning activities account for 41% of overall water consumption, making it the biggest consumption item. Sterilization and medical processing such as dialysis units also appear to involve a significant amount of water consumption (14%).

Verlicchi et al. (2) suggest that daily water consumption per bed varies between 200 and 1200 L, and that the lowest water consumption is observed in developing countries (200 to 400 L). The water consumption per bed in the United States is estimated to be around 968 L. (7). In their study conducted in 22 different hospitals in Trabzon, Topbaş et al. (8) found that the average monthly water consumption was around 1962 m^3. Another study conducted by Altın et al. (9) in various different hospitals in Sivas province found that the daily water consumption per bed differed between 480 and 839 L. It was established that 14.8% of such amount was used in kitchens/cafeterias while 13.0% of it in laundry.

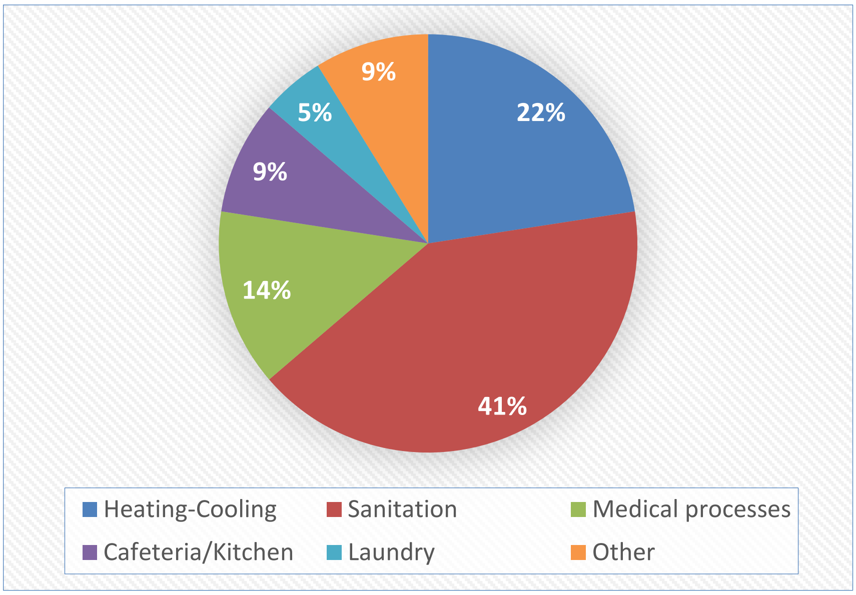

Figure 1. Distribution of water used in Bostonian hospitals in accordance with hospital activities (4).

There are significant changes in water consumption in hospitals throughout the year. For instance, while the daily water consumption in a 600 bed university research and application hospital in Zonguldak is around 410 m^3 during the winter months, it increases by 21.6% and reaches 523 m^3 during the summer months (Figure 2). In the light of the aforementioned evidence, the daily water consumption per bed varies between 683 and 872 L. Despite the fact that the increasing dehydration in summer months contributes to such increase, the main factor behind it is understood to be the irrigation activities.

Water consumption in hospitals change significantly throughout the day as well. A study conducted by Altın et al. (10) found that the water consumption in hospitals is significantly higher in the morning hours (especially between 08:00 am and 11.00 am) than other hours of the day, while the peak hours are identified during the time between 16:00 pm and 19:00 pm in the afternoon. The reason for such high water consumption during those designated hours in the morning and afternoon is attributed to the fact that the patients are treated and laboratory analyses performed during these particular time frames. In this respect, the factors that have the most bearing on the amount of water used for such applications are identified as the number of beds, number of inpatients and nature of their treatment, age of the hospital, access to water, utilities available inside the building, corporate management policies and the overall operation of the building with an awareness to protect the environment, climate, cultural and geographical factors (6).

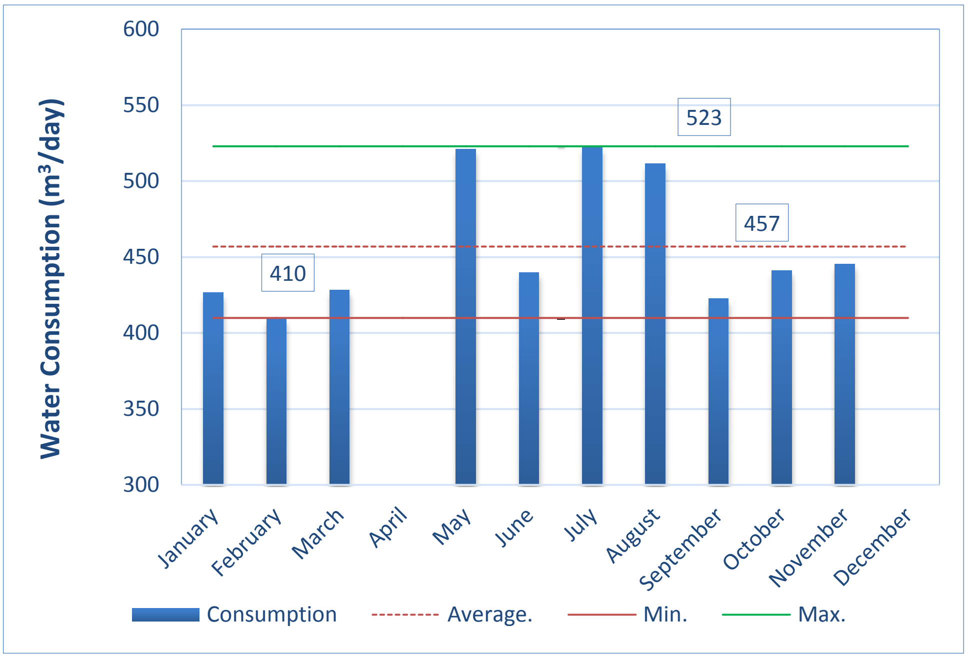

Figure 2. Monthly water consumption values in a university research and application hospital (Turkey)

The most fundamental approach to mitigating water consumption is to replace the old and worn equipment and fittings that are likely to cause water leakage with the new ones. The use of appropriate fittings in operation rooms while conducting disinfection procedures can help save a significant amount of water. Dialysis units consume about 120 to 800 L of water depending on the time and nature of the treatment. A large portion of such water is being used for water production through reverse osmosis system (11). The supply of healthy and sterile water into hospitals is considered as one of the most important problems. There are still debates over the protective measures intended for the elimination of Legionella related water pollution in hospital water supply systems and the types of disinfection systems to be installed for such purposes (12, 13). The pathogens such as norovirus, cryptosporidium, mycobacterium tuberculosis and mycobacterium other than mycobacterium leprae can also be considered to be in this group (14). Failure to facilitate effective disinfection for such microorganisms may result in fatal consequences in the health care institutions that accommodate a large number of patients with greatly reduced body resistance.

Wastewater Management in Hospitals

The wastewater discharged from hospitals consists of various kinds of water of originating from a good number of treatment and/or diagnosis departments such as laboratories, polyclinics, operating theaters, radiology units, medicine preparation units and blood transfusion centers (15, 16). As such they contain a good number of pollutants with different properties and environmental impact.

In general, the wastewater generated by hospitals can be divided into two categories, namely macro pollutants and micro pollutants.

Macro pollutants include;

- Physico-chemicals (pH, redox potential, conductivity, COD, BOD_5, TOC, SSM, ammonium, chloride and free chlorine)
- Microbiological macro pollutants (Coliforms, bacteria (Enterococci, Staphylococci, Shigella, Salmonella) and viruses) (17).

Micro pollutants include;

- Pharmaceuticals and personal care products (PPCPs) (antibiotics, anesthetics, analgesics and anti-inflammatories, cytostatic drugs (intended to inhibit cell development), β-blockers, anticancer medication and other pollutants (anti epileptic drugs, blood lipid regulating drugs, endocrine system drugs)
- Radioactive Substances and AOXs (chlorinating reagents, AOX and iodic x-ray, contrast agents)
- Disinfectants (quaternary ammonium compounds such as sodium hydrochlorides, aldehydes, alcohols and chlorophenols)
- Metals and heavy metals (metals such as Rb, Li, Sr, rarely found elements such as gadolinium, indium and osmium as well as Zn, Co, Pb, Fe, Cr, Ni)
- Endocrine Disruptive Agents (Phthalates, Bisphenol A, PVC, Triclosan, Trich (2-Chlorethyl) Phosphate, 4-Nonylphenol, PCBs, Dioxin, Furan, Alkylphenols) (17).

The examination of the pollutants potentially contained in hospital wastewater suggests that such wastewater can not be discharged directly into the aquatic and terrestrial ecosystems and that it may affect the performance of a wastewater treatment facility when discharged to such facility via sewer system and that the substances contained therein, especially the micro pollutants, can not be treated by conventional treatment techniques. For instance, pharmaceuticals can be treated in municipal treatment plants at the rate of 10 to 90% depending on their individual properties (2). For this reason, consideration is now given to the use of new technologies in the treatment of hospital wastewater. Some of these methods are listed as follows:

- Physico-chemical methods such as coagulation-flocculation (18, 9, 10), adsorption (19)
- Membrane biological reactor (MBR) systems (20)
- Reverse osmosis (21)
- Nanofiltration (19)
- Ozonation and advanced oxidation processes (22)

Not every wastewater coming from various different units of hospitals may contain most of the said pollutants. For this reason, the hospitals that have the means to collect wastewater separately allow reuse of water in activities such as cleaning, irrigation and toilet flushing through the employment of direct or partial treatment techniques on wastewater generated from various different units as gray water. For instance, the wastewater generated in dialysis units through reverse osmosis system is free of bacteria and different from that of household and industrial wastewater in terms of pH, turbidity and electrolytic properties and capable of being used as gray water in turf irrigation and toilet flush tanks (23, 24). In the similar vein, rain and flood water as well as the water leaking from condensers and pumps can be collected and used for fire extinguishing, irrigation, flushing, laundrette and boiler water preparation purposes (5). However, while 86% of the hospital administrators support the idea of reclaiming gray water, 38.7% of them are of the opinion that such water may still contain infected materials and thus cause infections to the patients or that gray water may end up being mixed with drinking water (6).

CONCLUSION

Hospitals are critically important in terms of public health as they consume vast quantities of water and generate equally vast quantities of wastewater. Since various different units in a hospital require different qualities of water, the costs of water supply and water treatment account for a large budget item. The settlements situated in the areas of water scarcity face problems in terms of sustainable water supply. Moreover, a large number of micro pollutants present in the hospital wastewater may also create significant environmental problems when discharged into the aquatic and terrestrial ecosystems. Conventional treatment methods fail to offer a permanent and definite solution to the said problems, and thus it becomes increasingly necessary to employ advanced treatment technologies which are costly and relatively difficult to operate. For this reason, introduction of a sustainable water and wastewater management system becomes a priority for hospitals in tackling such issues. In this respect, efforts should be made to develop saving measures intended for the reduction of wastewater generation; build an infrastructure that allows the collection of wastewater separately; and reduce the amount of water to be consumed and treated by reusing the suitable wastewater in some other activities. However, in order to put the activities intended for the reclamation of wastewater into practice, the negative psychological barriers erected in the minds of the hospital administrators should be eliminated first.

REFERENCES:

1. Watkins K. Human Development Report 2006-Beyond scarcity: Power, poverty and the global water crisis. New York, United Nations Development Programme Human Development Reports, 2006
2. Verlicchi P, Galletti A, Petrovic M, Barceló D. Hospital effluents as a source of emerging pollutants: an overview of micropollutants and sustainable treatment options. Journal of hydrology. 2010; 389(3): 416-428.
3. Faezipour M, Ferreira S. Assessing Water Sustainability Related to Hospitals Using System Dynamics Modeling. Procedia computer science. 2014; 36: 27-32.
4. Massachusetts Water Resources Authority. http://www.mwra.state.ma.us/04water/html/bullet1.htm. Accessed 13.02.2017.
5. VEH. Guidelines for water reuse and recycling in Victorian health care facilities: Non-drinking applications. Melbourne, Victorian Government Department of Health, 2009.
6. D'Alessandro D, Tedesco P, Rebecchi A, Capolongo S. Water use and water saving in Italian hospitals. A preliminary investigation. Annali dell'Istituto Superiore di Sanità, 2016; 52(1): 56-62.
7. Oliveira TS, Murphy M, Mendola N, Wong V, Carlson D, Waring L. Characterization of pharmaceuticals and personal care products in hospital effluent and waste water influent/effluent by direct-injection LC-MS-MS. Science of the total environment, 2015; 518: 459-478.
8. Topbaş M, Beyhun NE, Can G, Ucuncu SY, Kolayli CC, Karakullukcu S, Cankaya S. Water Management in the Hospitals in Trabzon Province. Journal of Environmental Protection and Ecology, 2016; 17(2): 772-780.
9. Altın A, Değirmenci M, Altın S. Hastane Atıksularının Arıtılması, Kayseri I. Atıksu Sempozyumu, 22-24 Haziran, Kayseri, 1998; 262-268. (in Turkish)
10. Altin A, Altin S, Degirmenci M. Characteristics and treatability of hospital (medical) wastewaters. Fresenius Environmental Bulletin, 2003; 12(9): 1098-1108.
11. Brown LH, Buettner PG, Canyon DV. The energy burden and environmental impact of health services. American journal of public health, 2012; 102(12): e76-e82.
12. Marchesi I, Ferranti G, Mansi A, Marcelloni AM, Proietto AR, Saini N, Bargellini A. Control of legionella contamination and risk of corrosion in hospital water networks following various disinfection procedures. Applied and environmental microbiology, 2016; 82(10): 2959-2965.
13. Ferreira AP. Risk and management in hospital water systems for Legionella pneumophila: a case study in Rio de Janeiro-Brazil. International journal of environmental health research, 2004; 14(6): 453-459.
14. D'Antonio S, Rogliani P, Paone G, Altieri A, Alma MG, Cazzola M, Puxeddu E. An unusual outbreak of nontuberculous mycobacteria in hospital respiratory wards: Association with nontuberculous mycobacterial colonization of hospital water supply network. International journal of mycobacteriology, 2016; 5(2): 244-247.

15. Verlicchi P, Al Aukidy M, Galletti A, Petrovic M, Barceló D. Hospital effluent: investigation of the concentrations and distribution of pharmaceuticals and environmental risk assessment. Science of the total environment, 2012; 430: 109-118.
16. Amouei A, Asgharnia H, Fallah H, Faraji H, Barari R, Naghipour D. Characteristics of Effluent Wastewater in Hospitals of Babol University of Medical Sciences, Babol, Iran. Health Scope, 2015; 4(2): e23222.
17. Yaşar A, Doğan EC, Arslan A. Hastane Atıksularında Makro ve Mikro Kirleticiler ve Arıtma Seçenekleri/Macro and Micro Pollutants and Treatment Options in Hospital Wastewaters. Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 2016; 29(2): 144-158.
18. Altın A, Değirmenci M. Hastane Atıksularının Koagülasyon ve Flokülasyon Yöntemiyle Arıtılabilirliğinin İncelenmesi, I. Uludağ Üniversitesi Çevre Mühendisliği Sempozyumu, 24-26 Haziran, Bursa, 1996; 143-153.
19. Bolong N, Ismail AF, Salim MR, Matsuura T. A review of the effects of emerging contaminants in wastewater and options for their removal. Desalination, 2009; 239(1): 229-246.
20. Radjenovic J, Petrovic M, Barceló D. Analysis of pharmaceuticals in wastewater and removal using a membrane bioreactor. Analytical and bioanalytical chemistry, 2007; 387(4): 1365-1377.
21. Oppenheimer J, Stephenson R, Burbano A, Liu L. Characterizing the passage of personal care products through wastewater treatment processes. Water Environment Research, 2007; 79(13): 2564-2577.
22. Ikehata K, Jodeiri Naghashkar N, Gamal El-Din M. Degradation of aqueous pharmaceuticals by ozonation and advanced oxidation processes: a review. Ozone: Science and Engineering, 2006; 28(6): 353-414.
23. Agar JW. Conserving water in and applying solar power to haemodialysis: 'green dialysis' through wiser resource utilization. Nephrology, 2010; 15(4): 448-453.
24. Tarrass F, Benjelloun M, Benjelloun O. Recycling wastewater after hemodialysis: an environmental analysis for alternative water sources in arid regions. American Journal of Kidney Diseases, 2008; 52(1): 154-158.