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Original Article

Wastewater Characteristics and Appropriate Method for Wastewater Management in the Hospitals

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Abstract

Background: Hospitals generate relatively large quantities of wastewater that may contain various potentially hazardous materials; therefore the proper management of hospital wastewater is essential.

Methods: In this cross-sectional study, the quality and quantity of wastewater in the hospitals of Tehran University of Medical Sciences (TUMS), Tehran, Iran, were studied and the suitable method for wastewater management in the hospitals was determined.

Results: Monitoring of pH, TSS, BOD_5, COD and total coliforms indicated that the quality of wastewater in the hospitals was similar to domestic wastewater. The wastewater production in the hospitals was determined to be in the range of 398 to 1090 L/d/(occupied bed). The study on wastewater treatment and disposal methods demonstrated that discharge to municipal wastewater collection system is the best alternative for wastewater management in the hospitals, but this approach is not applicable for all of the hospitals. Baharloo, Cancer Institute, Children, Farabi, Imam Khomeini, Razi, Roozbeh, Shariati and Valiasr hospitals can be connected to municipal wastewater collection system at present.

Conclusion: It is recommended that these hospitals' wastewater be discharged to municipal wastewater collection system. Amir Alam, Bahrami, Mirza Koochak Khan and Sina hospitals will be able to discharge their wastewater into sewerage network at second phase of Tehran sewerage project (in 2010) and Arash Hospital will be able to discharge its wastewater into sewerage network at third phase of Tehran sewerage project (in 2015). These hospitals have to select onsite separate wastewater treatment alternative.

Keywords: *Hospital, Wastewater, Waterquality, Wastewater treatment, Iran*

Introduction

Improvement of the hospital waste management has received increasing attention throughout the world since hospitals generate a considerable amount of medical waste each year (1-3). The generation of waste in hospitals has been increasing due to development in medical services and products. Nowadays several thousands of ingredients are used for drugs in even more products (4, 5).

In hospitals, a variety of substances besides pharmaceuticals are used for medical purposes as diagnostics and disinfectants. Besides the active substances, formulation adjutants, pigments and dyes are also drug components. Disinfectants, in particular, are often complex products or mixtures of active substances. After application, many drugs are excreted non-metabolized by the patients and enter into wastewater. Diagnostics agents and disinfectants also reach the wastewater after as residual quantities (6, 7). First findings of pharmaceuticals in the aquatic environment were reported in the 1970s. Some investigations represented the existence of drugs in public owned treatment works effluents (5, 8-10).

Hospital wastewater has similar quality to municipal wastewater, but may also contain various potentially hazardous components including, mainly, microbiological pathogens, hazardous chemical compounds, disinfectants, pharmaceuticals and radioactive isotopes. Indeed hospital wastewater may have an adverse impact on environmental and human health; therefore, the proper management of hospital wastewater is needed (2, 11, 12).

The objective of this research was to study the quality and quantity of wastewater in the hospi-

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tals of Tehran University of Medical Sciences (TUMS) and to determine the suitable method for wastewater management in the hospitals.

Material and Methods

In this research, wastewater management in the hospitals of TUMS was investigated in 2006. All of the hospitals are located in Tehran, Iran. This study was cross-sectional in design.

Study on wastewater quality

Bahrami, Imam Khomeini, Razi, Shariati, Sina and Valiasr hospitals were selected for monitoring of wastewater quality characteristics. The chemical and microbial parameters of pH, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD) and total coliforms were measured in the collected wastewater samples. All of the examinations were performed according to the instructions of "Standard Methods for the Examination of Water and Wastewater" (13).

Study on wastewater quantity, treatment and disposal

A questionnaire was provided for determination of wastewater production per occupied bed and used method for wastewater treatment and disposal in the hospitals of TUMS. Wastewater treatment and disposal and sludge management procedure were investigated in Amir Alam, Cancer Institute, Children, Farabi, Imam Khomeini, Mirza Koochak Khan, Razi, Roozbeh, Shariati, Sina and Valiasr hospitals. The questionnaire included several questions about hospital specifications, quantity of water consumption, wastewater treatment processes, effluent disposal, sludge processing and disposal. Wastewater quantity was studied in Amir Alam, Children, Farabi, Mirza Koochak Khan, Razi, Roozbeh, Shariati and Sina hospitals. The bills of water in three recent years were used to determine the water consumption of the hospitals. The conversion factor of water to wastewater was estimated with regard to some criteria such as number of occupied beds, personnel and wards, green land area to hospital area ratio etc. The wastewater flowrate per occupied bed was obtained from multiplication of water consumption per occupied bed by conversion factor.

The alternatives of hospital wastewater management were compared from the viewpoint of economical and health risk aspects, then the best option of wastewater management were introduced for each of the hospitals.

Results

Study on wastewater quality

Fig. 1a shows the average pH value of wastewater in the investigated hospitals. The average TSS concentration of wastewater in the studied hospitals is illustrated in Fig. 1b. The average BOD_5 and COD concentrations of wastewater in the studied hospitals are represented in Fig. 1c. The average COD to BOD_5 ratio (COD/BOD_5) of wastewater in the studied hospitals is illustrated in Fig. 1d. The average number of total coliforms of wastewater in the studied hospitals is presented in Fig. 1e.

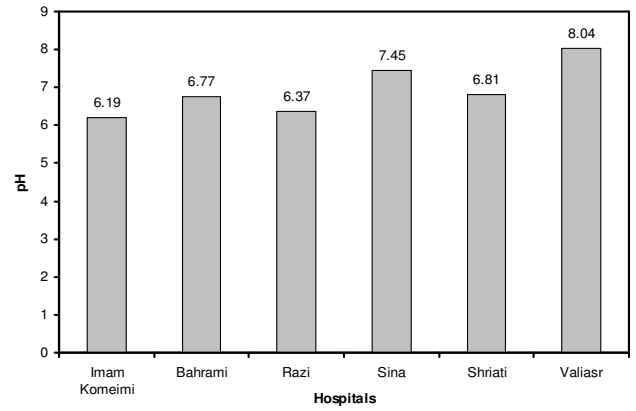
Study on wastewater quantity

Fig. 2a illustrates the average quantity of water consumption per occupied bed in the investigated hospitals. The conversion factor of water to wastewater was obtained to be in the range of 75-84%. The average quantity of wastewater production is showed in Fig. 2b.

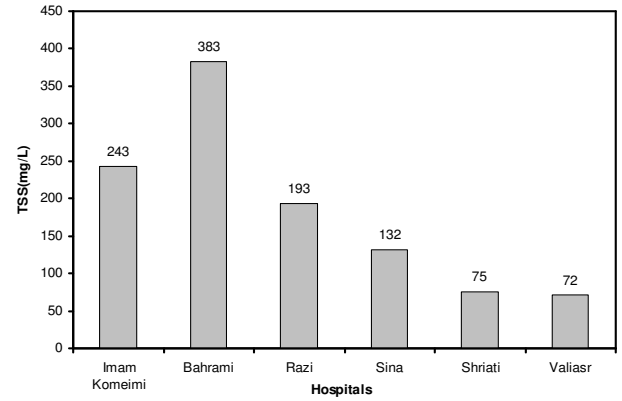
Study on wastewater treatment and disposal

Cancer Institute, Children, Imam Khomeini, Razi, Shariati, Sina and Valiasr hospitals had the wastewater treatment plant using activated sludge process as the secondary treatment. Efficiency of the wastewater treatment plants was not appropriate. For example, In Shariati Hospital, efficiency of the wastewater treatment plant in removal of BOD_5, COD and TSS was obtained 78, 74 and 49%, respectively. In all of the treatment works, operation problems such as raising and bulking of sludge in secondary clarifiers and production of undesirable odors were observed. The most important reasons of the low efficiency were improper plant operation and maintenance and problems in plant design and construction. In Shariati Hospital, the effluent was being discharged to

cesspool and the sludge produced in the wastewater treatment plan was being disposed to Kahrizak Landfill without any processing and stabilization. Amir Alam Hospital had primary wastewater treatment plant including septic tank and chlorination basin. Efficiency of the system was very low and was not a suitable system for hospital wastewater treatment. In Mirza Koochak Khan Hospital, the untreated wastewater was being discharged to cesspool. In Roozbeh Hospital, the kitchen wastewater was being passed through grease removal chamber and then discharged to municipal wastewater collection system. The wastewater produced in the other places such as baths and laundry was being discharged to cesspool without any treatment. In Farabi Hospital, the raw wastewater was being discharged to municipal sewerage network.



(a)



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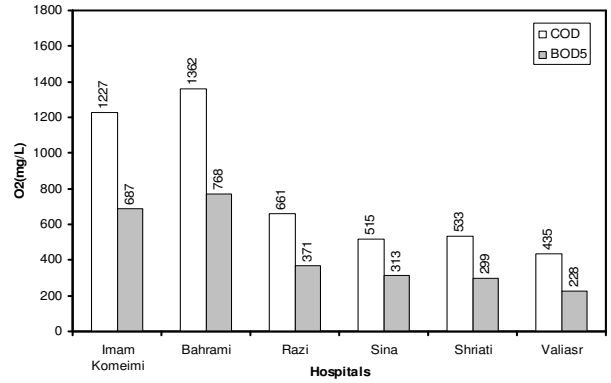

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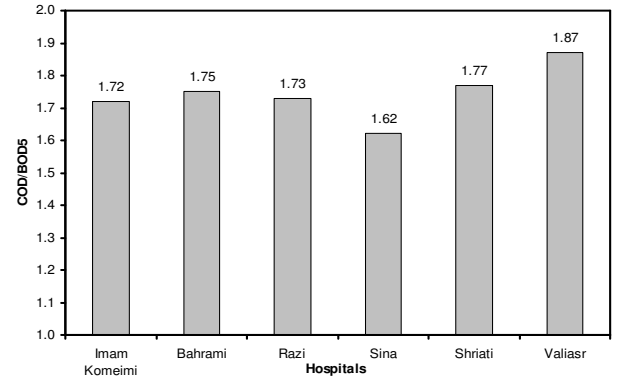
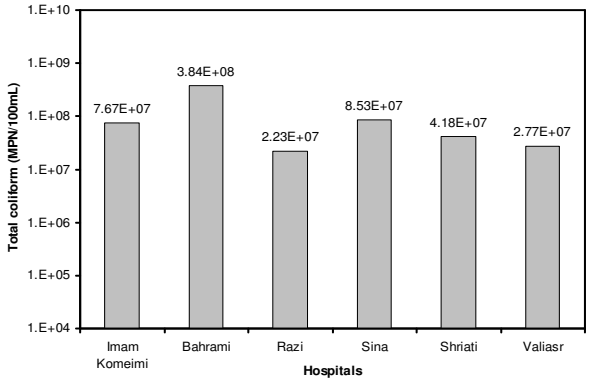


(d)



(e)

Fig. 1: Quality characteristics of wastewater in the investigated hospitals; (a) pH, (b) TSS, (c) COD and BOD_5, (d) COD/BOD_5 ratio and (e) Total coliforms

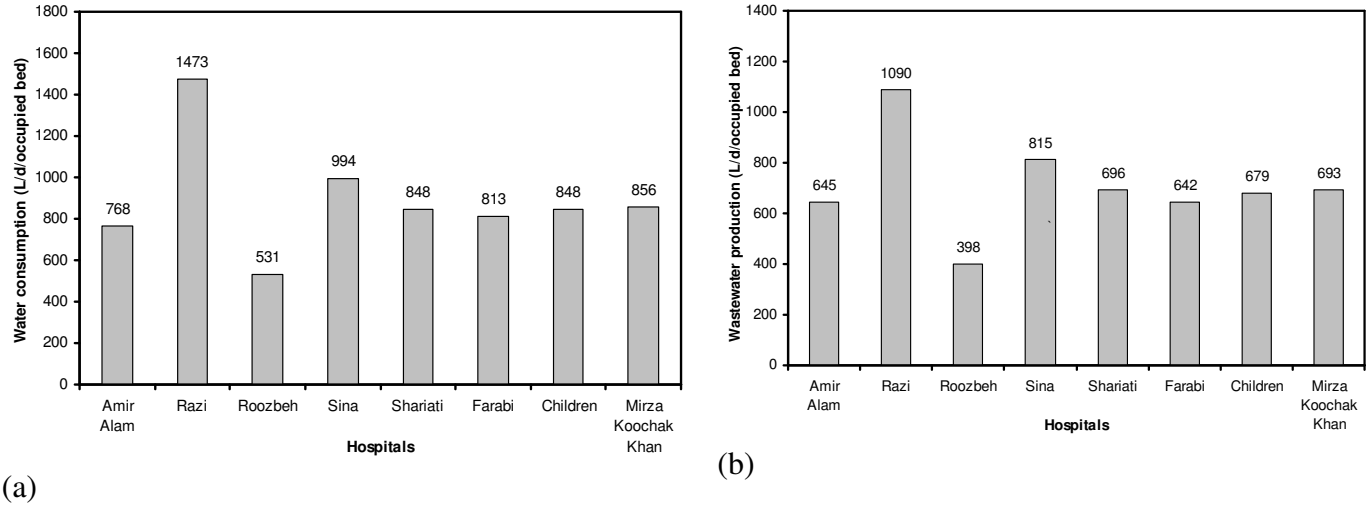


Fig. 2: Water consumption (a) and wastewater production (b) per occupied bed in the investigated hospitals

Discussion

Study on wastewater quality

The acidic or basic wastewater damages the wastewater collection and treatment facilities and prevents the biological treatment processes (14). According to Fig. 1a, the minimum and maximum pH values were observed in the wastewater of Imam Khomeini Hospital and Valiasr Hospital, so the average pH value of wastewater in these hospitals was obtained to be 6.2 and 8, respectively. The mentioned range (6.2-8) is suitable from the viewpoint of wastewater treatment processes and comparable to pH of domestic wastewater (15). The equivalent results were obtained in the other studies. Clean Technology Consultant (16) determined the wastewater pH value of a hospital in Thailand to be 7.2. In Indonesia, the range of pH in the hospital wastewater was obtained 5.9-12.5 (17).

One of the common parameters used in defining a wastewater is TSS. According to Fig. 1b, the minimum and maximum TSS concentrations were obtained in the wastewater of Valiasr Hospital and Bahrami Hospital, so the average TSS concentration of wastewater in these hospitals was obtained 72 and 383 mg/L, respectively. The average TSS concentration of domestic wastewater is in the range of 120-400 mg/L that is comparable to the results obtained in the investigation (15). Moersidik (17) studied the wastewater quality of a hospital in Indonesia. In the hospital, the TSS concentration was determined to be in the range of 36-269 mg/L. Also the TSS concentration of a hospital wastewater in Thailand was 103 mg/L (16). Wangsaatmaja (18) obtained the TSS concentration of a hospital wastewater in Bangkok to be 90 mg/L.

The parameters of BOD_5 and COD are widely used to characterize the organic matter content of wastewater (15). According to Fig. 1c, the minimum and maximum concentrations of BOD_5 and COD were obtained in Valiasr Hospital and Bahrami Hospital, so the average concentrations of BOD_5 and COD in Valiasr Hospital were determined to be 228 and 435 mg/L, respectively and the average concentrations of BOD_5 and COD in Bahrami Hospital were obtained 768 and 1362 mg/L, respectively. The average BOD_5 and COD concentrations of domestic wastewater with regard to its pollution strength are in the ranges of 110-350 and 250-800 mg/L, respectively (15). In the most of the hospitals, the BOD_5 and COD concentrations of wastewater are almost equal to the domestic wastewater values. Clean Technology Consultant (16) determined the BOD_5 and COD concentrations of a hospital wastewater to be 113 and 232 mg/L, respectively. In Bangkok, the BOD_5 and COD concentrations of a hospital

wastewater were 300 and 430 mg/L, respectively (18). According to Fig. 1d, the COD/BOD_5 ratio was in the range of 1.6-1.9, however in the domestic wastewater, the ratio is around 2.3. Therefore, the organic matters in the hospital wastewater had higher biodegradability in comparison with domestic wastewater. The high biodegradability of organic matters is very desirable from the viewpoint of wastewater treatment and promotes the efficiency of wastewater treatment plants (15).

The principal area of concern is wastewater with a high content of enteric pathogens, including bacteria, viruses, protozoa and helminths, which are easily transmitted through water. Wastewater of hospitals treating patients with enteric diseases is a particular problem during outbreaks of diarrhoeal disease. Therefore the microbial quality of hospital wastewater is very critical (19, 20). In this research, total coliforms were selected as indicator organisms. According to Fig. 1e, the minimum and maximum numbers of total coliforms were obtained in the wastewater of Razi Hospital and Bahrami Hospital, so the average number of total coliforms in these hospitals wastewater was obtained to be 2.2×10^7 and 3.8×10^8 MPN/100mL, respectively. The average number of total coliforms in domestic wastewater is in the range of 10^6-10^{10} MPN/100mL that is comparable to the results obtained in the investigation.

Study on wastewater quantity

Water consumption in a hospital is depend on several parameters including type of supplied medical services, number of beds, personnel and wards, social, cultural and economical condition of society etc (16). According to Fig. 2a, b, the minimum and maximum quantities of water consumption and wastewater production per occupied bed were observed in Roozbeh Hospital and Razi Hospital, so the average quantity of water consumption and wastewater production in Roozbeh Hospital was obtained to be 531 and 398 L/d/(occupied bed), respectively and the average quantity of water consumption and wastewater production in Razi Hospital was obtained to be 1473 and 1090 L/d/ (occupied bed), respectively. In hospitals of the United States, quantity of wastewater production per personnel and per bed has been estimated 40 and 1000 L/d, respectively (15). Clean Technology Consultant (16) determined the wastewater production of a hospital in Thailand to be 904 L/d/bed. In Bangkok, the quantity of hospital wastewater was 1182 L/d/bed (18).

Study on wastewater treatment and disposal

Cheremisinoff and Shah (21) stated the assessment of the risk of hospital wastewater is based upon dilution. In developed countries, most hospitals are connected to relatively large municipal wastewater collection systems and hospital wastewater represents only a small fraction of the volume of sewage. Therefore, the risk of hospital wastewater is at least because of the most dilution. Smaller systems may be more hazardous owing to smaller volumes of wastewater and hence, less dilution of contaminants. A major concern in the disposal of hospital wastewater is that hospitals have their own sewage treatment facilities. Furthermore, smaller systems are less efficient and may permit the discharge of infectious agents into groundwater and other environments which may be a hazard for both hospital personnel and the nearby community.

The study on wastewater quality indicated that the wastewater quality in the hospitals of TUMS was similar to domestic wastewater quality; therefore according to directions of Iranian Water & Wastewater Company, wastewater management in the hospitals has not limitation for onsite separate wastewater treatment or discharge to municipal sewerage network. Environmental risk assessment and economical evaluation of wastewater treatment and disposal methods (data not shown) demonstrated that discharge to municipal wastewater collection system is the best alternative for wastewater management in the hospitals, but this method is not applicable for all of the hospitals. Baharloo, Cancer Institute, Children, Farabi, Imam Khomeini, Razi, Roozbeh, Shariati and Valiasr hospitals can be connected to municipal wastewater collection system at present. It is suggested that these hospitals are connected to municipal wastewater collection sys-

tem. Amir Alam, Bahrami, Mirza Koochak Khan and Sina hospitals will be able to discharge their wastewater into municipal wastewater collection system at second phase of Tehran sewerage project (in 2010) and Arash Hospital will be able to discharge its wastewater into municipal wastewater collection system at third phase of Tehran sewerage project (in 2015). These hospitals have to select onsite separate wastewater treatment method. In these hospitals, establishment of wastewater treatment plant or upgrading of existing wastewater treatment plant and improvement of operation and maintenance practices by employment of experienced operators is needed for observance of effluent discharge standards.

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