



Estimations and analysis of medical waste amounts in the city of Istanbul and proposing a new approach for the estimation of future medical waste amounts



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ABSTRACT

The goal of this work was to estimate the yearly total medical waste amounts for hospitals and other healthcare institutions, and yearly averages of daily unit medical waste amounts per hospital bed using the data from medical waste collection, treatment and disposal establishments for last 18 years in Istanbul, Turkey. The estimations were based on the number of medical waste bags that were collected from hospitals and healthcare institutions and then transferred to either a medical waste incinerator or to an autoclave sterilization facility in Istanbul during the last 18 years. Hospitals were divided into 5 categories; dialysis, specialty, educational state university and state hospitals, non-educational state and non-educational private hospitals. Specialty hospitals were psychiatry, physical therapy, eye, dermatology, women care, child care, occupational diseases and lung hospitals. Results from this study indicate that the yearly total estimated medical waste amounts from hospitals have increased from approximately 5307 tonnes in 2000 to 22,755 tonnes in 2017. The yearly averages of daily unit medical waste amounts per hospitals bed have increased from 0.43 kg/bed-day in 2000 to 1.68 kg/bed-day in 2017. The other goal of this work was to propose and show a new (novel) relationship between the yearly estimated medical waste amounts and daily generation rates and yearly populations for the estimation of future medical waste amounts. Simple statistical evaluations of the estimated data were done and equations of the approximated linear lines were obtained. These evaluations indicated strong matches with the points of estimations. High degree of coefficients of determinations also showed strong relationships between variances. These figures and equations can be used for the estimation of future trends in order to facilitate better medical waste management practices.

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1. Introduction

Istanbul is the largest city of Turkey located on the very South-eastern border line of Europe and Northwestern border line of Asia, with a total area of 5400 km². At the end of the year 2017, the population was over 15 million. There are currently 289 hospitals and more than 8000 healthcare institutions in the city. The number of hospitals and healthcare institutions continue to increase in response to the increasing need for medical treatment and population increase. Not only are patients that reside in Istanbul utilizing hospitals and healthcare institutions for diagnosis and treatment but also patients from other parts of Turkey and the surrounding European and Middle Eastern countries are considering treatment in Istanbul's hospitals. During the last 17 years, the number of hospitals has increased by 70%. This increase in the number of

hospitals and healthcare institutions has resulted in an increase in the amount of medical waste needing management. Medical wastes, if not properly handled and disposed of, have the potential to cause high risks of infection and injury and may represent serious health hazards to health personnel (Mohee, 2005). Proper management of medical wastes requires the appropriate storage, collection, treatment and disposal techniques in order to minimize the health and environmental risks associated with medical wastes.

The first Turkish Medical Waste Control Regulation was adopted in 1993. In the Regulation, detailed procedures about the classification of the wastes and practices such as collection, transportation, and temporary storage of the wastes within the institutions and the transportation of them to the final treatment and disposal facilities were explained. The methods of treatment and disposal also described in detail in the last part of the Regulation. This Regulation was updated in 2005 to meet the EU legal framework of health-care waste management. This last Regulation

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described the principles for collection, transportation, temporary storage in health-care facilities, and treatment/disposal activities. According to this same Regulation, wastes from hospitals and health-care institutions were separated into 4 categories; domestic, medical, hazardous and radioactive wastes. The domestic, hazardous and radioactive wastes are never to be mixed with the medical wastes. The Regulation also subdivided medical wastes as pathologic, infectious and sharps/puncturing materials and stipulated separate collection followed by incineration or proper sterilization. This Regulation is being continuously updated to adapt to changing conditions. This paper only focuses on the medical waste part of the Regulation.

Although there is a clear definition and defined category of medical wastes in the Regulation, most of the domestic and recyclable wastes generated at the hospitals and medical institutions are still mixed with infectious and pathologic type of wastes. For example, [Kılıç \(2004\)](#) and [Zeren \(2004\)](#) did a survey of medical wastes of 197 hospitals and 401 clinics in İstanbul and showed that while approximately 35% of the materials were in the medical waste category, the remaining 65% were characterized as domestic and recyclables. The detailed medical waste characterization for İstanbul was presented by [Alagöz and Kocasoy \(2008\)](#). The WHO also estimated that only 15% of medical wastes can be considered as hazardous materials that may be infectious, toxic, or radioactive. Of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste ([WHO, 2018](#)).

Approximately 72 tonnes of medical wastes are being currently collected from hospitals and healthcare institutions daily in İstanbul. İstanbul Metropolitan Municipality's (IMM) affiliated environmental company İstaç, is currently fulfilling all collection activities for 289 hospitals and more than 8000 healthcare institutions. Before 2013, İstaç was responsible for collecting the waste from hospitals with a bed capacity of more than 20, while 39 district municipalities were responsible for the collection of waste from small healthcare institutions with less than 20 beds and other health related institutions with no beds at all.

There has been only one medical waste incineration facility in operation with a daily capacity of 24 tonnes for treatment and disposal of medical wastes until 2013. This capacity was not adequate to handle the increasing demand of medical waste treatment and disposal. The collected amounts exceeded the treated and disposed of amounts in 2005. New alternatives for treatment and disposal were urgently needed. [Alagöz and Kocasoy \(2007\)](#) investigated alternative treatment and disposal methods for the increasing amounts of health-care waste in İstanbul. Out of several alternatives that were considered, the most appropriate and cost effective method for the final treatment and disposal of health-care waste was determined to be a sterilization unit. [Özkan \(2013\)](#) also investigated the most appropriate treatment/disposal alternative for medical waste by using two different multi-criteria decision-making techniques. Five different healthcare waste treatment/disposal alternatives including incineration, on-site sterilization, off-site sterilization, microwaving, landfilling were evaluated according to analytical network process (ANP) and ELECTRE. The evaluation indicated that off-site sterilization was found to be the most appropriate option for waste treatment/disposal. This result also highlighted the immediate need for a new sterilization plant. A new autoclave sterilization plant began service by IMM on April 2013. This plant can sterilize 100 tonnes of medical wastes daily. Total daily medical waste treatment capacity with the addition of the recent sterilization facility has been increased to 124 tonnes.

[Alagöz and Kocasoy \(2008\)](#) studied medical waste generation rates and characteristics at the hospitals and healthcare institutions in İstanbul, by surveys, questionnaires and face-to-face interviews. They also investigated collection, on-site handling, storage,

processing, transportation and treatment/disposal practices. It was observed that all the wastes (infectious, domestic and recyclables) generated at health-care institutions were collected together at the source of generation and then transported to a disposal/treatment facility. This practice increased the amount of waste that needed to be treated as medical waste. The unnecessary classification of domestic wastes as medical infectious wastes resulted in higher disposal amounts and costs and an increase in the emissions caused by their disposal.

While some hospitals were very careful performing the segregation of medical wastes from the other wastes, most of the hospitals and health care institutions were not as diligent with the separation of real infectious and pathogenic wastes from the non-infectious and non-pathogenic wastes (domestic wastes). As a result of these practices, a wide range of medical waste generation rates have been reported in the literature. For tracking waste disposal quantities, the average daily amount of medical waste generated per hospital bed as kg/bed-day is being reported in most of the literature. For example, [Mato and Kassenga \(1997\)](#) have investigated the unit medical waste amounts and reported very large ranges from 0.84 to 5.8 kg/bed-day. [Qdais et al. \(2007\)](#) surveyed the characteristics of the medical waste generated at the 5 Jordanian hospitals. They reported that infectious waste amounts were the highest, followed by sharps and finally pathological. Cytotoxic and pharmaceutical categories were the lowest. The average daily generation rates in terms of beds were also estimated for the hospitals involved in that survey. The average daily generation rates ranged from 0.29 to 1.36 kg/bed-day. [Liberti et al. \(1996\)](#) reported a range of 0.2–3.5 kg/bed-day in Italian hospitals. [Hsein et al. \(1998\)](#) stated that the infectious medical waste generated by hospitals in Taiwan ranges from 0.51 to 0.9 kg/bed-day. [Al-Zahrani et al. \(2000\)](#) estimated that the mean generation rate of medical waste from Saudi hospitals to be 1.13 kg/bed-day with a standard deviation of 0.96. In a medical waste survey, [Askarian et al. \(2004\)](#) reported that the rate of average infectious waste generated by the hospitals in southern Iran ranged from 0.24 to 1.69 kg/bed-day.

The amounts of medical wastes generated from İstanbul's hospitals and health-care institutions have been presented in various journal papers. For example [Bırpınar et al. \(2009\)](#) did a survey of 192 hospitals in İstanbul and determined an average generation rate of 0.63 kg/bed-day. Whereas, [Zeren \(2004\)](#) and [Kılıç \(2004\)](#)'s survey showed 1.85 kg/bed-day and 2.17 kg/bed-day for the European side and Asian side of İstanbul respectively.

Accurate information on the quantity and the characteristics of medical waste is necessary to assist in the determination of suitable disposal methods ([Uysal and Tinmaz, 2004](#)). However, most of the investigations in the literature relied on short-term surveys and questionnaires done at the hospitals. As a result of this practice there is a wide variation of reported medical waste generation rates. In order to more accurately estimate medical waste generation rates with more robust and reliable figures, the total yearly collected number of medical waste bags from hospitals and healthcare institutions were obtained and used in this study. This entailed utilizing the total yearly collected numbers of medical waste bags from each hospital and official yearly hospital bed numbers for the last 18 years. The total yearly treated medical waste amounts at the facilities were also obtained and used for the calculations. The collected amounts of medical wastes from the other approximately 8000 healthcare institutions were also estimated.

The objectives of this work were:

1. To estimate the total yearly amounts of collected medical wastes from the different categories of hospitals and to determine the yearly grand totals for all hospitals during the last 18 years;

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