Waste Management 79 (2018) 435–442

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Generation and composition of waste from medical histopathology laboratories

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ARTICLE INFO

Article history:
Received 10 April 2018
Revised 4 August 2018
Accepted 6 August 2018

Keywords:
Hazardous waste
Health care waste
Histopathology
Infectious waste
Medical waste
Toxic waste

ABSTRACT

The aim of this work was to record the quantities and composition of medical waste (MW) generated by public and private medical histopathology laboratories (HISTOLB) and to provide pertinent waste generation design coefficients (e.g. g/examinee) for those laboratories. This can be a useful coefficient when designing medical waste treatment facilities. The study was conducted on three public and four private HISTOLBs in the city of Thessaloniki (Greece) for a period of 5 months. One sampling week was selected randomly per month. During the study period, the examinees per week were 108 and 90 in the public and private HISTOLBs, respectively. According to the results, 57% of the total MW generated in both the public and private laboratories were toxic waste (TXW), namely the liquid formaldehyde that is used to preserve the tissue. The mixed hazardous waste (MHW) comprised 28% and 24%, respectively, of the total MW, in the public and private facilities, respectively. The infectious waste constituted around 15% of the total MW generated in both types of facilities. Urban type waste was always less than 4% by weight. The total mean MW generated in the public and private laboratories were 208 ± 543 (n = 1614) and 195 ± 512 (n = 1789) g/examinee, respectively. A large variance among the mean MW generation rates of the participating individual laboratories that belonged to the same category was observed. The dominant fraction of the infectious waste was the plastic containers that contained the tissue samples, being around 75% of the total infectious waste, followed by the latex gloves (being around 17% of the infectious waste).

1. Introduction

Medical waste (MW) or health-care waste is the solid and liquid waste generated from healthcare facilities. Medical waste includes a wide range of materials such as bandages, needles, body parts, blood, sample containers, chemical solutions, pharmaceutical products, medical devices and radioactive materials (WHO, 2018). According to the World Health Organization (WHO, 2018), approximately 85% of the MW are non-hazardous waste; therefore, only 15% have hazardous properties, namely being infectious, toxic and radioactive. However, this is a rough estimate and there have been several studies over the past decade to further investigate the generation rates and composition of MW from various types of healthcare facilities and activities (Komilis et al., 2017; Komilis, 2016; Al-Khatib et al., 2016; Voudrias and Graikos, 2014; Patwary et al., 2011).

The common sources of MW are the materials used to examine and treat examinees/patients as well as the waste produced from the medical staff. The types of waste produced by a health-care facility highly depend on local legislation and on the separation of MW that takes place within the facility (Tesfahun et al., 2014). Additional factors that affect MW generation are the type of the health-care facility, its status (public or private sector), and the percentage of consumable materials used in healthcare activities (Eleyan et al., 2013).

1.1. Categorization of medical waste

The most common categorization of MW around the world is into the hazardous and non-hazardous waste fractions (Komilis, 2016). In addition, infectious waste and/or sharps appear occasionally as separate categories. One of the most thorough categorizations of MW is described in the Greek legislation (HCMD, 2012). In Greece, MW are categorized into: (i) urban type non-hazardous medical waste and (ii) hazardous medical waste. The latter category is further grouped into (a) infectious waste (INFW), (b) infectious and toxic (mixed hazardous) waste (MXW) and the (c) solely toxic waste (TXW). Special waste (e.g. radioactive waste, batteries) is another separate category of the hazardous waste fraction.

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https://doi.org/10.1016/j.wasman.2018.08.012
0956-053X/

1.2. Scope of the work

No information appears to exist in the international literature on the generation rates and composition of MW generated by histopathology laboratories (HISTOLBs). Thus, the objective of this research work was to calculate the quantities and composition of waste generated by such laboratories after performing on site sampling and measurements. The ultimate goal of the work was to develop a waste design coefficient expressed in mass (g) of waste per examinee visiting a HISTOLBs in both the public and private sectors. This information is useful when it comes to assess medical waste quantities at the regional or national level (without performing expensive on-site weight measurements) and is also required to properly design medical waste treatment facilities and to charge medical clinics and laboratories according to their waste generation rates. The composition of MW was assessed by grouping MW according to the Greek legislation, namely into urban type medical waste (non-hazardous), infectious waste (hazardous), mixed hazardous waste and solely toxic waste (hazardous).

1.3. Tissue processing and medical waste derived from a typical histopathology laboratory

The medical sector of histopathology connects the clinical practice and the basic science of medicine. The goal of the histopathology sector is to investigate the tissue changes and to identify potential existing or emerging diseases. Another goal is to analyze the likely underlying tissue changes that could affect a body part or accompany a disease, and the likely appearance of medical symptoms (Kumar et al., 2007). The objective of histopathology is to perform biopsies on tissue fragments removed after surgeries. The biopsy samples are usually very small, from masses of mg to less than 1 g (Boshart et al., 1984; Shanely et al., 2014). In normal surgeries, on the other hand, the amounts removed can vary from a few grams to kilograms.

During a histological examination, the examinee's body part is delivered to the laboratory in a container soaked in a fixative material. The fixative material stops the autolysis of the tissue and preserves the structural stability of the cells. Typical fixative materials used in all HISTOLBs are aldehydes and particularly formaldehyde. The pathologist examines the sample and selects the whole or a part of the tissue for further processing and examination. The typical medical consumables used in the process are gloves, knife blade, cotton, cotton tissues, filter paper. Then, the sections of processed tissue are placed in a table tissue processor to carry out dehydration and refining of the cells, using ethanol and a mixture of three xylenes. The final stage of processing is the preparation of paraffin cubes that contain the tissue parts. Then paraffin cubes are cut into thin peels on a microtome and are placed on slide plates. The parts of the tissue will be painted with stains of hematoxylin and eosin. The histopathology medical staff examines, then, the final shape of the slide under a microscope.

Formaldehyde (CH_2O) is commonly used in HISTOLBs to preserve tissues. At room temperature, formaldehyde (FMLD) is a colorless gas with an irritating odor. Its code in the European Waste Catalogue is 18 01 06 and is designated as a hazardous waste in the European Waste Catalogue. Pure formaldehyde cannot be found in stores but is sold as an aqueous solution at a 30–50% purity (by weight). It is highly reactive, it readily undergoes polymerization, it is highly flammable, and can form explosive mixtures in the air. It decomposes at temperatures above 150 °C. Based on laboratory studies, the inhalation of FMLD under conditions that induce cytotoxicity and sustained regenerative proliferation is considered to present a carcinogenic hazard to humans. In HISTOLBs, the FMLD is separated from the tissue prior to analysis by screening. FMLD alone is then disposed of as a separate liquid waste, without including tissue parts.

2. Materials and methods

2.1. Case study and sampling period

The study was conducted on three public (one was in a university hospital and the other in general hospitals) and four private histopathological laboratories in the city of Thessaloniki. This is the 2nd largest city in Greece with a population of around 1,500,000 inhabitants. The selected laboratories were estimated to cover about 80–85% of the city's examinees that perform biopsy examination in the city's histopathology laboratories. The sampling period lasted five months (September 2017 to January 2018). One 5-day week per month (there was no operation of any of the laboratories on the weekend) was randomly selected per laboratory and daily measurements were performed during that week. The sampling periods per laboratory are shown in detail in Table 1. Eventually, a total of 25 daily measurements were performed per laboratory over that 5-month period. Biopsy samples were weighed per examinee on the same day that the analysis took place in each laboratory. The total amount of waste collected over a day was assigned to the number of examinees for that specific day. Thus, all results were eventually expressed in units of g/examinee. We preferred the expression on a per examinee basis, over the per examination basis, since the number of examinees is the most typical record that medical laboratories around the world keep. Thus, the "g/examinee" design coefficient is expected to be a more useful design coefficient compared to "g/examination". During statistical analysis, we used the weekly amounts of MW and the weekly number of examinees per laboratory to express the results in g/examinee and to perform statistical analysis. It is noted that the term "examinee" was preferred over the term "patient", since not all examinees can carry a disease or are actual patients. The capacities of the seven HISTOLBs and the corresponding sampling periods are included in Table 1.

2.2. Equipment used in the seven HISTOLBs

The types and numbers of equipment used per laboratory are included in Table 2. This information is provided to allow a rough estimation of the toxic liquid waste generated due to the disposal of the reagents used by the equipment of each laboratory. It is clarified that no direct measurement of that fraction was made since this information was not available by any of the laboratories involved in the study. This amount does not include the formaldehyde that was placed in the container that preserved the tissue which was measured separately and with precision every sampling day. A total of seven such equipment was recorded in the three public hospitals and five equipment were present in the four private laboratories. This difference in the ratio can be justified by the fact that some public hospitals are university hospital, accepting medical trainees, and usually have more medical staff than private laboratories. As a result of the above, more tissue processing equipment was found per public hospital compared to the private HISTOLBs in our study.

In total, there were twelve tissue processors in the seven HISTOLBs and there were three different types of tissue processing techniques applied by those tissue processors that could affect the volume of waste. For example, some of these models come in direct contact with the tissue casings, and some others just infuse the tissue casings with the liquid solution. In the first model type, the liquid solution is added to cover all the quantity losses from the processing activity. As soon as the principal liquid solution