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Characterization and leachability evaluation of medical wastes incineration fly and bottom ashes and their vitrification outgrowths

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ABSTRACT

The present investigation focus on the characterization and leachability evaluation of medical wastes incineration ashes and that of their glasses, produced during vitrification with soda lime recycled glass (SLRG). Two types of ashes were examined: A Fly Ash (MFA) derived from the incinerator waste gases de-dusting system (fabric filter dust collector), and a Bottom Ash (MBA) produced from the heavier particles of the agglomerated remaining matter, which are precipitated and accumulated usually in the combustion chamber. Glasses of various syntheses were obtained during the MFA and MBA vitrification with various amounts of silica scrap (20, 25 and 30 wt% for MBA and 50, 55 and 60 wt% for MFA). The characterization of both ashes and that of their vitreous products was carried out by means of chemical analysis and mineralogical analysis by X-ray diffraction. MFA microstructure and morphological characteristics were examined by scanning electron microscopy and transmission electron microscopy, whereas the corresponding of MBA and the produced glasses were studied in polished section through scanning electron microscopy. Their behaviour during leaching was determined by the Toxicity Characteristic Leaching Procedure test and the EN 12457-2 compliance leaching test and according to the results both ashes should be treated as hazardous wastes and in case of landfilling they should be disposed of at appropriate, regulation-prescribed waste dumps. On the other hand in case of their vitreous outgrowths, the trace elements detected in the leachates were well below the corresponding regulatory limits.

1. Introduction

The ability of a health unit to improve the quality of the health services and also to provide a reliable level of medical care not only refers to the medical and hospital services, but also expands to parallel or subsequent activities to their main field. One of these contiguous or resultant activities with significant impact on the environment and human health is the management of medical waste produced by hospitalization. According to the World Health Organization (W.H.O.) about 85 wt% of the waste generated at health units presents similar properties with the corresponding of municipal solid wastes. The remaining 15% is classified as hazardous, with properties such as infectivity, toxicity, carcinogenicity, radioactivity etc, thus requiring special treatment [1,2].

The term "Medical Waste" refers to all medical waste generated by Health Units, which have been mentioned in the waste catalogue of the Annex of the European Communities Decision [3]. In recent decades, the search for safe treatment and disposal of hazardous medical wastes is a major problem of the health sector worldwide and concerns not only the government mechanisms or the health unit's administration, but also the society as a whole. The problem has been aggravated by the emergence of new infectious diseases and the simultaneous lack of the appropriate infrastructure for the safe handling of hazardous medical waste. The risk, therefore, for the environment and human health degradation, due to the release of hazardous substances, arises from the inappropriate waste management practices used. On the other hand, proper medical waste management requires significant on-going funding and monitoring, thereby administrations of health facilities do not give the necessary priority to address this issue [4,5].

The main aim/objective of the present research study is to present the results obtained from a complete characterization and the leachability evaluation of medical wastes derived from incineration i.e. MBA and MFA along with their corresponding glasses (VMBA and VMFA), generated during their vitrification with SLRG. The existing management methods of medical-waste disposal have been repelled due to ineffective inactivation of the contained pathogenic microorganisms, thus, resulting in the risk of contagion of infectious diseases, either by direct contact through wounds, inhalation and ingestion or by indirect

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Fig. 1. Incineration ashes, produced during the combustion of medical wastes.

contact via the food chain or a host pathogen. The main acceptable alternatives available today are the methods of thermal treatment (incineration, pyrolysis, gasification) and the methods of sterilization (thermal, chemical disinfection), but mainly for the lower pathogen load wastes [6–9]. Incineration is considered among the best choices, carried out in many developed countries worldwide for the most of the health-care hazardous wastes, as it can thermally eliminate all pathogens and on the same time may decrease the waste weight more than 70 wt% (90%, in terms of their original volume) [10–14]. It is suitable for all kinds of medical wastes except for specific types such as radioactive, batteries, etc.

The main advantages of the incineration process are the volume reduction of the wastes, along with their sterilization and possibility of heat recovery or electricity. On the other hand, the risk of toxic gaseous emissions, the high operation and maintenance costs, as well as the demand for the management and the disposal of produced ashes may be considered its main disadvantages. It should be also noticed that in case the incinerator is not operating properly, large amounts of hazardous air pollutants, such as carbon monoxide (as a result of incomplete combustion), hydrochloric acid, heavy metals (mercury, arsenic, cadmium), dioxins and furans may be emitted [15–17]. One of the main drawbacks of the incineration process is that significant amounts of MBA and MFA, usually enriched with toxic substances, are produced. Their compositions can be either siliceous or calcareous as a result of the origin, containing also metal oxides of aluminium and iron. However, heavy metals usually remain in both ashes (MBA and MFA), as they cannot escape to atmosphere along with the gases, with the exception of the mercury, which remains in vapour state [12,18].

MFA has been classified as hazardous waste and it is usually handled separately from the ashes of the combustion chamber, in dry phase, mainly though cement or thermal solidification before its final disposal. In case of MBA, after removing from the main combustion chamber it is cooled by quenching. It can be handled in a dry or liquid state and finally transferred to closed drums or containers for storing.

Although the common practice of MFA and MBA disposal in secured landfills should be accompanied most of times from a stabilization/solidification pre-landfil treatment, there are only few studies investigating stabilization/solidification (S/S) of medical wastes with cement or other types of binder [19–21]. To the authors' best knowledge little attention has been given to MFA and MBA inactivation through vitrification process. In the present investigation MBA and MFA along with their corresponding glasses (VMBA and VMFA), generated during their vitrification with SLRG were characterized through chemical analysis, X-ray diffraction, scanning electron microscopy and transmission electron microscopy, whereas their leachability evaluation was carried out by applying the EPA Toxicity Characteristic Leaching Procedure test [22] and the BS EN 12457-2 compliance leaching test [23].

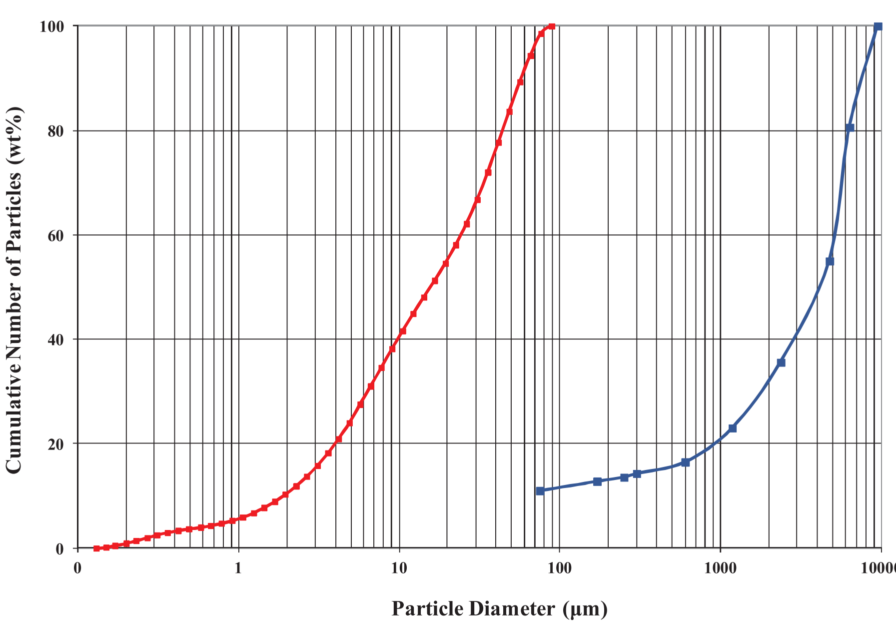

Fig. 2. Particle size distribution of MBA and MFA.