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A Review on The Combustion Systems in Medical Waste Management and Its Environmental Effects in Turkey

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Abstract: The number of hospitals in Turkey is increasing day by day. This increase has also led to an increase in waste load. Increasing waste load led to the initiation of waste management practices related to this issue in hospitals. The arrangements were made regarding medical waste management in Turkey for the first time in 1993. These regulations have been amended in accordance with the 2005 EU Environmental Directives. Both in Turkey and in the world, it can be said that the revised format of the medical waste management, depending on the technology. In this study, by considering the intended medical waste management in Turkey will focus on the potential harm to the environment. In addition, ashes remaining as a result of incineration should be evaluated in terms of environment. Therefore, the disposal of these ashes is also mentioned.
Keywords: Medical Wastes, Waste Management, Environmental Effects.

INTRODUCTION

When medical wastes which comprising of the health sector are not properly treated, they pose a great risk to the environment and human health. The solid, liquid and gas wastes originating this sector occur in large quantities. It can be said that one of the biggest reasons at the management of these wastes is that the underdeveloped or developing countries do not have sufficient knowledge and equipment in this regard. The development and implementation of the plans implemented for this, the effective treatment and disposal of medical wastes in line with the control of the relevant units in any country, are the basis of solving medical waste problems. Medical waste is an environmental hazard that needs to be handled scientifically and carefully. In addition, the developing technology has a great effect on the increase of a large part of these wastes. As a result, proper management of separation - collection - transport - storage - disposal processes in developed or underdeveloped or underdeveloped countries will enable these wastes to be controlled more regularly [1].

MATERIAL-METHOD

Medical Waste Characterization and Classification

If the definition of medical waste is based on; It generally includes anatomical wastes, pathological wastes, infectious wastes, hazardous wastes and other wastes. In addition to these, it can be found in household wastes with the implementation of medical activities. Although this situation is not desired, it can affect waste management in unconscious societies [2]. Due to the health problem caused by the AIDS (acquired immune deficiency syndrome) dilemma and other infectious diseases such as hepatitis B, the public's concern about the use of medical waste is gradually increasing[3]. In addition, it includes wastes (dialysis, insulin needles, etc.) that are seen as “small” or “dispersed” sources, e.g. after medical activities at home. In Figure 1, it was studied on the classification of medical wastes.

The concept of medical waste may differ for many people. Due to these differences, many medical waste management strategies emerge. This situation plays an active role in the emergence of

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differences in the management of medical waste [2]. Today, studies on the evaluation of waste are gaining a different dimension. Scientists now adopt environmentally friendly approaches rather than disposing of waste. In this regard, evaluation, transportation, disposal of medical wastes, etc. Minimizing the harmful effects that may occur in many stages is important in terms of its effects on the environment and human health. Failure to mix medical waste with hazardous and household waste will play an active role in preventing pathological waste from spreading. Thus, the control of medical wastes can be easier [4]. Medical wastes need to be classified according to their use, resources, storage and final disposal processes, taking into account the risk factors. The European Union attaches great importance to the classification of waste in the standards it creates.

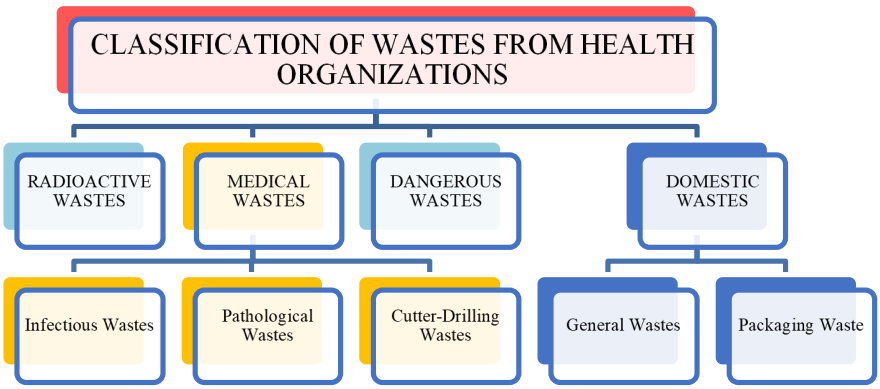

Figure 1. Classification of medical wastes[2]

If we classify medical wastes separately;

Infectious waste; Waste suspected of containing pathogens, e.g. wastes from isolation zones; laboratory cultures; materials, cloths or equipment used in contact with infected feces[5].

Pathological wastes; Tissue, organ, human fetus and animal corpses can be listed as blood and body wastes [5,6].

Genotoxic waste; Waste-containing substances with genotoxic properties (in treatment applications such as cancer treatment) [5].

Chemical waste; Wastes containing chemicals, laboratory reagents; solvents; we can classify them as expired or no longer needed disinfectants. In addition, disinfectants used for cleaning are in this group [5,6].

Heavy metal content wastes; Broken thermometers, Batteries in, Blood pressure dicators[5].

Pressure vessels; Gas cylinders, Gas cartridges [5].

Radioactive waste; These are solid, liquid or gaseous wastes used in laboratories or radiotherapy areas [5,6].

Cutting and Drilling Tools; Needles include cutting or piercing wastes such as other cutting piercing wastes, knives, infusion sets. These wastes are seen as high risk wastes [6].

Infectious or Potentially Infectious Waste; microbiology laboratory cultures, blood and placenta contaminated wastes, probes, bandages and bandages, feces and contaminated items, contaminated piercing and cutters, operating room wastes (disposable gowns, gloves and drapes), dialysis centre wastes, experimental animals wastes, bacteria and viruses conservative air filters are defined as infected wastes. In addition, infected waste must be disposed of in special bags. The features of these bags are; 150 µm thick, Tear and puncture resistant, Leak proof and transport resistant, 50-60 kg carrying capacity, It must have medical waste and international emblem on it [6].

Pharmaceutical wastes; All kinds of drugs used in the hospital, increased or outdated [6].

Medical Waste Resources

Turkey management of medical waste, prepared by the Ministry of Environment and Forestry prepaid medical waste is carried out by Regulation [4]. Medical wastes are divided into large-scale and small-scale. Medical waste sources are shown in Table 1.

Table 1. Medical waste sources[7].

Large Scale	Small Scale
University hospitals, general hospitals, regional hospitals, emergency services, health centers and dispensaries, maternity clinics, outpatient clinics, dialysis centers, first aid centers, transfusion centers, military medical centers, laboratory and research centers, morgue and autopsy centers, animal research and examination, blood banks and blood collection services, care centers for the elderly, etc.	small health institutions, specialized health institutions producing small amounts of waste, non-health activities (cosmetic ear-piercing and tattoo parlors, illegal drug users), funeral services, ambulance services, home treatments, etc., including intravenous and subcutaneous interventions.

Medical Waste Techniques

There are a few techniques used to minimize the damages that may arise from medical wastes. These are shown in Figure 2.

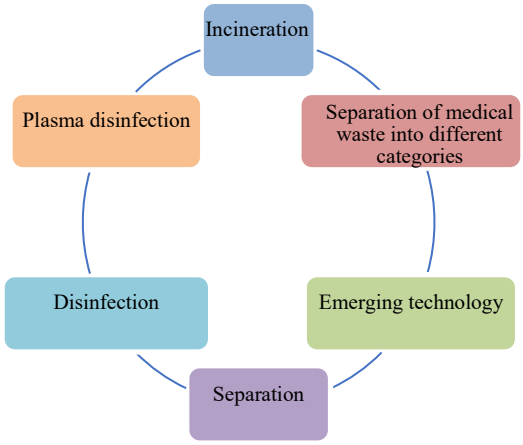

Figure 2. Medical waste management practices [8].

Plasma disinfection; air is used here as a fluid. This regulates the combustion process of the low temperature plasma produced in the plasma generator. During this process, medical waste must be mixed continuously. Thus, the heat and mass change that prevents energy loss is maximized, allowing the heat generated to be used as an additional source. It also prevents the release of irregular forms of substances such as NOx and dioxins into the atmosphere. Another important advantage compared to other combustion processes is that it has low energy consumption [8].

Medical wastes are divided into different categories; In healthcare facilities, infectious, pathological, cutting-piercing tools are collected in different containers. These containers are labeled closed, waterproof and in the same color, with the words "biohazard" on all types of medical waste. The size of the containers varies depending on the volume of waste. Specially produced containers are used for the needles used. The sorting, packaging, labeling and marking system involves categorizing medical waste as described. The categorization is done with the help of colored bags. It can be understood which disposal method will be used according to the colors. As for labeling and labeling, medical waste is known to have a biohazard symbol. Both packaging and labeling are accepted worldwide. The difference is the method used [8].

Disinfection; Chemicals such as chlorine dioxide, sodium hypochlorite or acetic acid are used to reduce the toxicity of some medical waste. For solid waste, disinfection is effective only if waste materials are broken down. Due to the chemical content of some disinfectants, disinfection of pharmaceutical, chemical and some types of infectious waste is not desired [8].

Developing technologies; These technologies include cutting and grinding of cutting-piercing tools. The shredding process is carried out with the help of blades at 1750 rpm and provides 80% reduction in the volume of waste. The steps included in the process are loading, shredding, heating,

sterilization, cooling, unloading, vacuum and unloading. The compact size of these types of tools allows them to be easily transported and used easily where desired. It will both lead to a reduction in waste transportation costs and a reduction in environmental impacts. This technology is currently applied in middle east countries such as Iraq, Jordan, Kuwait, Lebanon, Syria and the UAE. Another innovation is a mobile disintegration and chemical disinfection machine aimed at handling hazardous medical waste produced in the USA on site. The machine converts medical waste into disposable municipal waste, using disintegrants, which are then wetted with disinfectant spray and disintegrate into smaller particles immersed in a disinfection solution. The wet waste is then dried in a drying chamber using a hot flue gas [8].

Separation; Unless hazardous wastes are separated, they cause contamination in other wastes. In this way, the amount of waste will increase and the amount of toxic substance will increase. The separation process prevents the spread of the amount of toxic substances present. It both reduces the amount of waste and facilitates its transportation. Wastes are separated depending on the amount, composition and disposal method of the waste stream [8].

Incineration; is the process of removing waste in high temperature furnaces. It provides waste to be harmless as well as reducing the volume of waste mass by burning pathological and infectious waste or cutting-piercing waste. Incineration is suitable for 60% flammable waste. The furnaces used in incineration may vary depending on the type of waste. For example, while mobile combustion ovens are used for pharmaceuticals, diesel fuel combustion furnace called "MediBurn" is used for wastes originating from small scale enterprises. One of the important advantages of this process is that it reduces the waste volume remaining after incineration by 50-400 times. Also, incineration is one of the most effective methods of disinfecting medical waste. Among its disadvantages are high costs, smoke production, air pollution. If burning is carried out in small enterprises such as hospitals instead of large-scale, furan and dioxin production. This poses a risk for both environmental pollution and human health. Among the causes of dioxin and furan formation; frequent start-up and shut-down operations, less emission controls, poor combustion control, differences in waste feed composition can be shown [8].

RESEARCH AND RESULTS

Medical Waste Incineration

Since medical waste incineration is a safe and effective method, it is used in many countries. Briefly, medical waste incineration is defined as the process of incineration of specific wastes, including pathological, trace chemotherapy and non-hazardous pharmaceutical wastes. It is not possible to burn pharmaceuticals and specific pathological wastes completely in incineration systems. Therefore, other techniques are used to make or destroy medical waste [9].

This system is a thermal process that involves the incineration of waste at high temperatures. Burning can be done by ignition, electricity or a combination of these. The dual chamber pyrolytic incinerators, which can be specially designed to incinerate the incinerators, medical waste, are divided into 3 categories as single chamber furnaces with static grills used in the case of not using the thermal incinerator, rotary furnaces that separate toxic substances and heat resistant chemicals [1,4]. All combustion furnaces have primary and secondary firing chambers. The inadequate combustion process is very important as it causes the formation of toxic substances such as dioxins and furnlar. Toxic substances such as these can cause air pollution or remain in the ash that is formed. It is potentially dangerous as there will be heavy metal content in the ash left after the combustion process. This can lead to contamination of storage sites [5].

Emission Quantities from Combustion

Standards in the EU or USA are used for gas emissions such as ashes, halogens, heavy metals, dioxides, NOx, SOx, carbon and hydrogenated halogens formed as a result of combustion. It is very important for the environment and human health that the gases coming out of incinerators comply with these standards. There are limit values for gas emissions in Table 2 and Table 3 [10]. In addition, there are limit values related to these gases in the Medical Waste Control Regulation in our country.

Table 2. Emission values of incinerators [10].

Polluting	Small diameter incinerator (<91 kg / hour)	Medium size incinerator (> 91-227 kg / hour)	Large-scale incinerator
Emission limits for new incinerators (for plants to be built after June 1996)			
Solid matter	115mg/m³	69mg/m³	
Carbon monoxide (CO)	40ppmv	40ppmv	
Dioxins / furans	125ng/m³ CCD/CDF or 2.3ng/m³TEQ	125ng/m³total CCD/CDF or 2.3ng/m³TEQ	125ng/m³total CCD/CDF or 2.3ng/m³TEQ
Hydrochloric acid (HCI)	100ppmv or %93 decreasing	100ppmv or %93 decreasing	100ppmv or %93 decreasing
Sulfur dioxide (SO2)	55ppmv	55ppmv	55ppmv
Nitrogen oxides	250ppmv	250ppmv	250ppmv
Lead	1,2mg/m³ or %70 decreasing 0,16mg/m³ or %65 decreasing 0,55mg/m³ or%85 decreasing	1,2mg/m³ or %70 decreasing 0,16mg/m³ or %65 decreasing 0,55mg/m³ or%85 decreasing	1,2mg/m³ or %70 decreasing 0,16mg/m³ or %65 decreasing 0,55mg/m³ or%85 decreasing
Emission limit values for existing incinerators (for plants built before June 1996)			
Solid matter	115mg/m³	69mg/m³	34mg/m³
Carbon monoxide (CO)	40ppmv	40ppmv	40ppmv
Dioxins / furans	125ng/m³ CCD/CDF lor 2.3ng/m³TEQ	125ng/m³ CCD/CDF or 2.3ng/m³TEQ	125ng/m³ CCD/CDF or 2.3ng/m³TEQ
Hydrochloric acid (HCI)	100ppmv or %93 decreasing	100ppmv or %93 decreasing	100ppmv or %93 decreasing
Sulfur doxite (Sox)	55ppmv	55ppmv	55ppmv
Nitrogen oxides	250ppmv	250ppmv	250ppmv
Lead	1,2mg/m³ or %70 decreasing	1,2mg/m³ or %70 decreasing	1,2mg/m³ or %70 decreasing
Cadmium	0,16mg/m³ or %65 decreasing	0,16mg/m³ or %65 decreasing	0,16mg/m³ or %65 decreasing
Mercury	0,55mg/m³ or %85 decreasing	0,55mg/m³ or %85 decreasing	0,55mg/m³ or %85 decreasing

	Polluting	Emission limits
	Emission limits for existing incinerators that are less than 908kg / week away from settlements that can burn waste and meet rural criteria (for facilities built before June 1996).	
	Solid matter	197mg/m³
	Carbon monoxide (CO)	40ppmv
	Dioxins / furans	800ng/m³ total CDD/CDF or 15ng/m³TEQ
	Hydrochloric acid (HCI)	3100ppmv
	Sulfur dioxide (SO2)	55ppmv
	Nitrogen oxides	250ppmv
	Lead	10mg/m³
	Cadmium	4mg/m³
	Mercury	7,5mg/m³

While dust removal is applied for the removal of fly ash formed in flue gas cleaning, washing is performed for other gas emissions. Although oxidation technique is not recommended for removal of CO and NOx, it is emphasized that the production of these pollutants should be kept to a minimum [10].

Table 3. EU Standards for Incinerators [10].

Emisyon Değeri (mg/m³)	**Daily Average (mg / m³)**	**Half Hour Avg. (mg/m³)**	**Average Value (mg/m³)**	**Average Value (mg/m³)**
Total dust	10	30 -	-	**-**
Total organic carbon	10	20	**-**	**-**
Chlorinated compounds	**10**	**60**	**-**	**-**
Fluorinated compounds	**1**	**4**	**-**	**-**
Sulfur oxides as SO2	**50**	**200**	**-**	**-**
Carbon monoxide	**50**	**100**		
Mercury	**-**	**-**	**0,05**	**0,1**
Cadmium and Telium	**-**	**-**	**Tot. 0,05**	**Tot. 0,1**
Lead, chromium, copper				
Manganese, nickel				
Arsenic, antimony, Cobalt				
Vanadium and Tin	**-**		Tot. 0,5	Tot. 1,0
Dioxins and Furans	**-**	**-**	0,1	**-**
Temperature in the combustion bakery: 850Cº or >%1CI:1100Cº				

Environmental Pollution Resulting from Combustion

The fact that my medical waste collection management is not adequate and regular in health institutions, in other words, poor implementation of solid waste management will cause both healthcare workers and the environment to be negatively affected. Another consequence of poor management of solid waste management is that these wastes, which are taken to landfills, cause the transport of pollutants such as insects or by transporting pollutants through the wind. This can lead to pollution of groundwater and soil, and thus of the ecosystem. Also, uncontrolled transfer of medical wastes to landfill sites can lead to a pollution transport from soil to the sea. This can pose a major threat to the environment and fisheries. This suggests the possibility that combustion products and incinerators may be inappropriate or inadequate, ie at relatively low temperatures (below 1200 ° C). In addition to soil and water pollution, a pollution factor is created for air. Thus, they can be a very high source of emissions. In addition, they are dioxins or mercury carcinogens caused by incineration of medical waste. In a study by the US Environmental Protection Agency, medical waste incinerators are considered an important source of dioxin and mercury pollution in the environment and food stocks [1].

Disposal of Waste Resulting

After washing the ashes that are formed as a result of the incineration process and the wastewater that occurs after the cooling process, it is subjected to chemical neutralization process without sewage. Thus, acid neutralization and precipitation of salts are provided. Also, the disposal of hazardous waste (flying ashes, sludge, etc.) should be sent to licensed hazardous waste disposal facilities. Since the ashes formed in the combustion process are less dangerous than fly ash, they have been used in the construction industry in many businesses or trials. However, it was later suggested that the toxic substances of these ashes could leak. These ashes are disposed of in specially designed landfills in many countries after the thought that leachate groundwater will be contaminated. It has led to the emergence of more environmentally friendly incinerators in order to minimize the environmental and

health impacts occurring in industrially developed places. This situation has led to increased cost of incinerators and research of new clean technologies [10]. Also for infectious and non-hazardous wastes; In many different fields such as biogas production, landfill and fertilization, their expenses have been revealed depending on the amount of solid waste [5].

THE METHOD OF APPROACH TO PROCESSING MEDICAL WASTE INCINERATION IN TURKEY

In general the majority of landfill waste sites in Turkey, a portion of municipal solid waste sites, are removed using a small portion of the combustion system. The incineration of medical wastes is evaluated under the permits and licenses of the Ministry of Environment and Urbanization [11]. In addition, medical wastes are handled within the scope of 'Medical Waste Control Regulation' and 'Waste Management Regulation'.

The main reason for combustion systems being less preferred is due to the high initial investment and operating costs. Istanbul is the city that is mostly on the agenda regarding medical waste incineration [11]. In the study conducted in Istanbul, there are opinions that the amount of medical waste has increased. The main reason for this is that sanctions imposed in public or private hospitals and other private institutions are subject to strict inspections. However, this increase can be said to be at low levels compared to developed countries. Some of the medical waste in Istanbul is disposed of in incineration plants. With the incineration process, the volume of the majority of the waste is reduced. In addition, electricity is produced at the facility. The electricity obtained is used in administrative buildings as well as in the facility [12]. In the general framework after the sterilization process instead of working in the burning process for the disposal of medical waste in Turkey it is sent to the application of the burial or landfill. We can say that the main reasons for not using the combustion system in our country are the high initial investment and operating costs.

Although the countries that experienced in the current system of medical waste collar, Turkey, in this case for the first time in 1997 in Izmit, Kocaeli (IZAYDAS) began with the establishment of combustion systems. In addition to the advantages of combustion systems, it has disadvantages to the environment and human health. For example; Permanent organic pollutants such as PCDD / PCDF can appear during the combustion process. Although these compounds are not fully proven, they are among the threats to human health. It is in the direction that the pollutants formed in one of the studies conducted to reduce the environmental effects of the combustion process can pass into the human or living body through plants [13].

CONCLUSION

Disposal of medical waste and selection of appropriate disposal methods is a global problem. Burning is one of the disposal processes. Waste rate is significantly reduced by incineration. However, the gas emissions generated during the combustion process cause serious damage to the environment. Permanent pollutants are also among the important pollutants that can occur at this time. Many gas emissions such as these can enter the human or any body indirectly when released into the air. In our country, there are not many studies on medical waste incineration. High operating costs as well as initial investment costs make us think about the preference of such applications. It is considered as a suitable method for wastes such as pathological wastes, which are among the classes of medical wastes and which we will take into the dangerous category. However, when considering cost-based methods, alternative methods are preferred or more environmentalist approaches are adopted. However, even a single facility where such processes are carried out can significantly harm the environment.

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