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An Investigation on The Reduction and Management of Medical Solid Wastes

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Abstract: During the activities of hospitals, medical waste is generated as a natural result of the process. Although medical wastes are produced as a result of activities to improve health quality, they have a high risk of health problems if they are not managed appropriately. More and more importance are given to medical waste management in terms of health risks in the world and in our country and academic studies are carried out in terms of the most appropriate disposal methods. Disposal methods in addition to the superiority of appropriate methods in eliminating health risks, disposal costs also require multidisciplinary management in order to impose financial burden on health institutions. University hospitals need management because of the environmental impacts they generate due to high rates of waste generation. The most important environmental risks arising from health institutions are medical and hazardous waste management problems. Wastes from university hospitals are grouped in terms of their nature and capability. Domestic wastes, packaging wastes, medical wastes, hazardous wastes, radioactive wastes, wastewater containing high concentrations of tissue and body fluids are produced from health institutions. Wastes from university hospitals are subject to waste management applied in other health institutions in that they are the same in character as wastes from health institutions. It is better to supervise and implement the management of wastes from university hospitals. Because large amounts of waste are produced, the results are more traceable and more appropriate in terms of results. In this study, besides the reduction of hospital-generated wastes, the studies carried out for the evaluation and the studies that can be done were evaluated.
Keywords: Medical waste, solid waste, recovery, waste management, university hospital

INTRODUCTION

All human activities are result with environmental effect. Although solid wastes are produced as a result of activities to improve life quality people, which have a risk of environmental problems if solid wastes are not managed appropriately by the local or central government. Really important to arrange to solid waste management for the health risks which contain in the investigation studies are performed by the most appropriate disposal methods. However, proper disposal methods reduce the health risks of solid waste. Solid waste disposal costs impose additional financial coast on municipality institutions. For this reason, multidisciplinary solution methods are needed for solid wastes. Because health facilities produce high amounts of waste, they need management in terms of environmental impacts that it causes. It is important that environmental risks arising from health institutions are medical and hazardous waste management problems.

As a result of medical activities, wastes that may pose a danger to the environment and health of living organisms are created due to examinations and treatments carried out to reduce human health problems and eliminate potential risks. Wastes generated during health activities have a higher potential for infection and injury. The actions involved in the implementation of effective medical waste management programs, both short and long term, require multi-disciplinary cooperation and interaction at all levels. Policies that can effectively manage the process from production to disposal of medical wastes should be identified. The established policies should be coordinated with the management practices implemented locally. Local capabilities and opportunities should be identified and applicable programs should be monitored. All stakeholders involved should be involved and trained [1].

Medical wastes from the wastes from hospitals should be managed as they will have negative effects on the environment and human health. With the technological advances in the medical sector, there have been significant increases in waste types and quantities. Medical waste producers are obliged

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to ensure that they do not adversely affect the quality of the receiving environment in all processes from the production of medical waste to disposal and to establish all measures in a way that will not harm the health of the living [2].

In medical waste disposal, incineration was a preferred method without detecting the harmful effects of incineration plants and during periods of low awareness. Alternative technologies have started to be preferred due to the high cost of filtering harmful emissions caused by combustion. Disposal options implemented in the world are affected by the influence of many issues such as local, geographical, financial and development. Disposal takes place within the framework of local facilities. Medical wastes which are in the status of hazardous wastes originating from health institutions are managed within the framework of local facilities and capabilities in terms of minimization and disposal methods.

Contaminated Wastes

Contaminated wastes have the potential to cause disease in humans. Medical materials contaminated with blood, blood products and body fluids have the potential to host microorganisms. Wastes that are suspected to come into contact with microorganisms such as bacteria, viruses, parasites and fungi with potentially pathogenicity are infected wastes (*eg*, the needles used in HIV-positive patients will stick to the patient or staff). This includes wastes suspected of containing pathogenic microorganisms that may cause disease (blood and body fluids with serological risk).

Infected wastes include the following types of waste: Infectious samples, cultures, blood and blood products produced as a result of laboratory studies.

Surgical or autopsy wastes (*eg*. disposable waste contaminated with sponge, pads, hemovac, intravenous needles and body fluids) and even daily use of infectious patients should be considered as infected waste. All wastes of patients in infection services and infection boxes are considered to be infected:

Wastes from persons receiving dialysis treatment and infectious disease agents (*eg*. forks, spoons, intravenous needles attached to patients' bodies, filters and sets used in the dialysis machine, box liners, contaminated liquids with the patient and all materials). Tuberculosis infected patients who are infected with MDR positive, IE the personal use of patients in the stage of infection, masks and all wastes used in daily use shows infected [3].

Pathological wastes

Pathological wastes refer to anatomical parts separated from body integrity as a result of surgical operations or physical trauma. These wastes consist of amputated hand, arm, leg and tissue samples taken for biopsy purposes [3]. Pathological wastes should be considered as a sub-category of medical wastes. However, they are usually classified separately. Special methods are used for disposal. Pathological wastes may contain healthy body parts that are generated during medical procedures or produced during medical research [3].

Pathological wastes are generally disposed of as incineration or burial by special methods due to their character separated from the infected wastes. While infected wastes are disposed of in sterilization facilities in our country, pathological waste disposal in these facilities is prohibited and technically not suitable. In addition, the status of foetuses in the elimination of pathological wastes in our country constitutes the need for regulation. Pathological waste; Human tissue, organs and body parts or fluids are biopsy, autopsy waste (*eg*, foetal, amputated arm or leg, body parts, etc.).

Chemical waste

Chemical wastes include solid, liquid and gaseous chemicals that have expired or have reached the end of their useful lives. Chemical wastes are considered hazardous waste if they contain one or more of the following properties. They are flammable, explosive, corrosive, toxic, carcinogenic, mutagenic, teratogenic, genotoxic, etc. wastes with harmful effects. Toxic (toxic); Corrosive (e.g. acids with pH <2 and bases with pH> 12), Easily flammable (flammable below 21 °C), Reactive (explosive, capable of reacting with water, impact sensitive), Non-hazardous chemical wastes contain chemicals such as sugar, amino acids and certain organic-inorganic salts. Hazardous chemicals used in health facilities are listed below [3].

Medical Facilities Producing Medical Wastes

Medical wastes are classified according to their origin and amount of formation and divided into three groups. In the regulation of control of medical wastes are given following Table [4].

Table1. Medical Wastes Producing Medical Facilities

1) Health Institutions Producing High Amount of Waste	2) Health Institutions Producing Moderate Waste	3) Health Institutions Producing Small Amount of Waste
a) Hospitals and clinics of the Faculty of Medicine,	a) Oral and dental health hospitals and centres, medical centres, dispensaries,	a) Other health care units (doctor's offices, dental and oral health practices, etc.),
b) Training and Research Hospitals	b) Outpatient and outpatient treatment centres,	b) Physical therapy centres,
c) Maternity hospitals and clinics,	c) Morgues and autopsy centres,	c) Home treatment and nurse services,
d) Oncology and Private Hospitals,	d) Nursing homes and nursing homes,	d) Pharmacies,
e) State and Military Hospitals.	e) Medical and biomedical laboratories,	e) Ambulance services
	f) Blood banks and transfusion centres,	
	g) Emergency and first aid centres,	
	h) Dialysis centres.	

Microbiological and Epidemiological Risks of Medical Wastes

Medical waste generated as a result of the health care services carried out in health institutions poses various risks. These risks can reach an epidemiological frequency spreading from patients and employees to the general population. Due to contaminated medical waste, diseases such as reproductive system, respiratory system, central nervous system caused by pathological microorganisms have negative effects on general body systems. While pathogen and infectious agents are usually expressed, pathogenic microorganisms transmitted through blood come to mind. Patients diagnosed and treated for these diseases are at risk due to medical waste caused by diagnosis and treatment, including their companions and their relatives, personnel working in every staff in the health facility and their relatives.

The microorganisms mentioned in medical wastes firstly create infection risk in the environments where they are produced, that is, in hospitals. The mentioned microorganisms are infectious. Necessary trainings should be given to health workers about general hospital infections caused by medical waste. The use of personal protective equipment should be encouraged. Medical wastes produced should be removed from the health facility in the most appropriate way and time. The receiving environment must be disposed of in a way that does not adversely affect the character of the environment.

Effects of Medical Wastes on Environment and Public Health

In addition to the risks posed to health by people, waste from health institutions can have negative effects on environmental health. For example, carcinogenic gases such as dioxins and furan which may arise as a result of incineration of medical wastes threaten human and environmental health [3] storage facilities constructed in areas with high ground water levels may have negative effects on water quality. Hazards that may arise from inappropriate medical waste management can be grouped under four main headings [5].

INTEGRATED WASTE MANAGEMENT

Developing technologies in recent years have also affected the health sector. Most of the developing technologies take place in the sector as disposable materials. The increase in these disposable products also led to an increase in the amount of waste. Wastes from health institutions contain potential risks that may be harmful to human health throughout the process due to the risk of infection and the risk of injury. With appropriate waste management, methods can be developed that eliminate potential risks and do not involve new risks. In general, countries prefer the most economical methods of medical waste management [6]. In 1992, the United Nations Conference on Environment and Development identified the measures to be taken for waste management by Agenda 21. Implementation and measures to prevent and reduce the generation of waste, and the disposal of waste to be environmentally safe to take risks in the form of recommendations are recommended [7].

Medical Waste Management

The technologies developed in the health sector in recent years have increased the amount and variety of disposable materials used in our country and health activities. The increase of these disposable products has also increased the amount of waste. Wastes from health care facilities need to be managed carefully from cradle to grave because of the risk of infection and the possibility of injury. With appropriate waste management, methods that eliminate potential risks and do not include new risks are applied. In general, countries prefer the most economical methods of medical waste management [6]. Medical waste management is a dynamic process starting from the purchasing process to the final disposal. The adoption of the final outcome by the parties at each stage of the process is important for the success of the process. Measurement and inspection activities should be carried out in order to evaluate the point reached as a result of the planning. It is important to include the amount of waste to be produced per bed or bedside in the waste management plan. Minimization studies should be given importance to reduce the determined amounts.

Waste Minimization

The most important method of reducing medical wastes is the identification of wastes. The main purpose of waste management is to prevent the formation of wastes, to take measures to minimize the amount of waste in case it cannot be prevented and to show the methods for implementation. The waste separation process should be carried out and monitored in all units. The goal of waste minimization is to create less waste or hazardous waste. For this, it is necessary to start waste reduction methods from the purchasing process and decision-making stages. The processes recommended by the World Health Organization for medical waste minimization are as follows [3].

• Minimization in the formation phase: The amount of waste that can be generated can be reduced by applications such as reducing the use of single-use materials or preferring long term products. In the purchasing process, products that cause mass production of less waste should be preferred.

• Recycling: Recyclable materials with a long use period should be preferred at the purchasing stage.

• Decision-making processes: MSDS forms should be requested in purchasing processes for chemical materials and non-hazardous or less hazardous chemicals should be preferred. The substitution methodology should be applied. Plastic bottles instead of glass as serum can be tried as a method to reduce the mass of waste.

• Production planning: Wastes should be classified according to the identification studies. Necessary equipment and training support should be provided. Other hospital wastes collected together with medical wastes have to be evaluated in medical waste category.

Waste reduction, the source producing waste will always be profitable in terms of reducing the cost of disposal and reducing the risk of hazardous wastes generated in the purchase of raw materials and treatment of wastes generated [3].

I- Components of Successful Waste Minimization Program: Efficient waste minimization programs an important element of the minimization strategy is the definition of the first one. Because many wastes that are considered as medical waste are actually household or packaging waste. The components of successful waste minimization are as follows [3] :

a) In the production planning process, when the identification of infected waste is made, waste separation will be realized correctly.

b) Recycling of packages; especially pharmaceutical packages are treated as infected waste. The issue should be taken into account with the necessary identification and training.

c) Classification should be carried out in accordance with identification studies,

d) There should be directives indicating the separation of waste,

e) Trainings on waste segregation and hazards,

II- Basic Benefits of Medical Waste Reduction: waste reduction processes, especially the special process of disposal ensures that the production of required wastes is under control. Methods such as production planning, substitution, waste separation, long-life material usage, recyclable material preference will reduce the amount of waste that may occur. Reducing the amount of waste produced reduces waste management costs. As waste minimization eliminates waste disposal costs, it also positively affects the economic sustainability of health facilities financially [8]. (Eskitürk, 2015).

III- Processes in Waste Reduction: Production planning: The purpose of production planning is to determine and reduce the amount of waste materials in the first area at the purchasing stage. In this method, substitution is frequently used. It is the preferred stage of materials that do not generate waste or produce less waste or technologies rather than materials with high potential to generate waste. It is a very effective method.

Separation: In the reduction or prevention of the amount of waste produced, it is primarily the separation of wastes suitable for identification studies. Wastes allocated at the source reduce the amount of wastes applied by special disposal methods. All staff working in the hospital are natural members of the waste segregation process. For example, if a staff working in intensive care throws the medication packages into the red medical waste collection container instead of blue, that package will now be treated as infected waste, which will increase the amount of infected waste. Waste management trainings, especially in intensive care and operating room personnel, should be repeated at a certain time. It is thought that the amount of waste production per personnel in the intensive care and operating rooms is high.

IV Recycling and reuse: Recycling and re-use is applied in many materials, especially surgical hand tools in the health sector. However, it is necessary to comply with the sterilization protocols. Because the problem that will occur during sterilization causes infection. While recycling is preferred in formaldehyde-style chemicals, reuse is common in medical and surgical hand tools. The packaging and containers of the materials used are suitable for waste that is not hazardous to recycling and contamination risk. Return to dangerous and licensed [3].

Waste Separation

The locations and numbers of the collection equipment to be placed in the places where waste is produced in health facilities should be determined in cooperation with the infection committee and the waste management unit. Direction beacons and markers should be placed where these collection equipment is placed. These marks should indicate which wastes will be disposed in which colour trash. Implementation controls should be carried out along with activities to promote waste segregation. Hazardous wastes should be collected with equipment suitable for identification. Medical waste should be collected in red bags with an international biohazard emblem [4].

Domestic general wastes originating from health institutions are collected in black plastic bags separately from medical, hazardous and packaging wastes. Domestic wastes collected separately are transported in the unit by means of transport and taken to the temporary waste depot or container and stored separately temporarily. Domestic wastes are not mixed with medical wastes during collection. In case of mixing, they are considered as medical waste.

Recycling waste paper, cardboard, plastic and metal packaging wastes are collected separately from other wastes in blue plastic bags provided that they are not contaminated. Glass serum bottles and pharmaceutical packaging wastes in the medical material content are considered as packaging waste provided they are not contaminated.

Cutter and perforating wastes are separate from other medical wastes, puncture, tear, breakage and explosion-proof, waterproof and leak-proof, cannot be opened and mixed on the "International Biohazard" emblem "Attention! Cutter and Perforated Medical Waste" is collected in boxes or containers made of plastic or laminated cardboard with the same characteristics. Waste, colour bags, waste bags and the required wastes in them are listed below [4].

- Black bags should contain general and domestic waste
- Blue bags should contain packaging and recycling waste
- Red bags must contain infected waste
- Green bags should contain non-infected waste
- Radio Orange bags must contain radioactive waste.

Onsite Collection of Medical Wastes

Medical wastes are collected at certain hours on the route determined by the personnel specified in the unit waste management plan. Wastes without barcodes or labels should not be taken from the services. The collected waste is placed in the medical waste storage. Accumulation of waste at production points should not be allowed. Medical wastes should be collected from the units and vehicles which are made of wheeled, covered, stainless metal, plastic or similar materials which are easy to clean

and disinfect and that are reserved for this job [4]. Vehicles must be disinfected after collection. Other waste should not be allowed on medical waste transport vehicles. The medical waste collection vehicle should be orange. Waste handling personnel should be provided with personal protective equipment in accordance with the provisions of the control of medical wastes and must be in special clothing. Vaccination work schedules, training notes and training participation schedules should be provided for the protection of collection personnel in the personal file.

METHODS OF MEDICAL WASTES DISPOSAL

The general purpose of the final disposal of hazardous wastes and medical wastes is to make harmful components of wastes into products if it is possible to make them hazardous to human and environmental health [22]. Disposal methods used for infected and penetrating-cutting wastes originating from health institutions disinfection, autoclaving, landfill, microwave radiation and incineration. The disposal methods used for pathological wastes in medical wastes are burial and incineration [9]. Facilities producing medical and hazardous wastes are obligatory to store the wastes until the municipality. According to [4], health institutions have a capacity of more than 20 beds. The properties of the warehouse to be constructed are listed below.

a) Temporary waste storage shall be constructed as a closed space with two compartments. Medical waste is stored in the first compartment and domestic waste is stored in the second compartment.

b) The volume of the temporary waste storage shall be at least two days of waste.

c) The floor and walls of the tank are covered with a solid, impermeable material that does not hold microorganisms and dirt and is easy to clean and disinfect.

d) There is adequate lighting and passive ventilation.

e) Warehouse doors are opened outwards or made sliding. The doors are always clean and painted. The International Biohazard Colour in Black “Attention! Medical Waste”.

f) Store doors are closed and locked at all times. The warehouse and its doors are constructed in such a way that no animals can enter.

g) The interior and doors of temporary waste depots shall be constructed in such a way.

h) Temporary waste depot.

i) It cannot be constructed near the places where there is no traffic, such as a temporary hospital, where the hospital is located.

j) Cleaning and disinfection of the compartment where medical wastes are placed shall be done dry. The compartment is cleaned, disinfected and if necessary, disinfected following discharging of waste. After tearing or discharging a bag containing medical waste, the spilled waste is collected and the equipment is immediately disinfected.

k) There is a drainage system with a grid connected to the sewer and a pressurized water faucet. The compartment is cleaned following discharging, if necessary disinfected and disinfected.

l) Cleaning equipment, protective clothing, waste bags and containers are stored close to temporary waste storage [4].

Transportation of medical waste to the final disposal site

Medical and hazardous wastes from health institutions. The exterior of the vehicles must be painted orange. There should not be a clamping mechanism, attention should be paid when stacking. Waste loading should be made intact. The internal surface of the waste can be easily cleaned and disinfected with a smooth surface. It should not contain vertical corners and the intersecting surfaces. The International Biohazard can emblem written in black letters “Caution! Medical Waste” [4].

Thermal Processes

These processes (thermal energy) are used to destroy pathogens by means of heat. It is the most common method of disposal. This category can be divided into low thermal and high thermal design. Low thermal processes are sufficient for the disposal of microorganisms, while high thermal processes are used to burn and melt wastes. Melting by heat treatment is a process made by applying the heat treatment in an oxygen-free environment by increasing the temperature of the material from low to high temperature.

In general, low temperature thermal technologies are applied between 100 ° C and 180 ° C. Low heat treatments can take place as wet and dry heat treatments. Wet heat treatment is carried out by means of steam disinfection and an autoclave system. Microwave treatment is again a wet treatment method. Because the disinfection process is made by producing hot water with microwave energy. Dry heat treatments are processes without water and steam. Treatment process in dry heat treatment; infrared and resistant thermal radiation occurs by heat conduction or by diffusion [10].

Chemical Processes

In the treatment of medical wastes in chemical processes; The use of dissolved chlorine dioxide, sodium hypochlorite and disinfectant occur with the use of per-acetic acid, lime, ozone gas or dry inorganic chemicals (e.g. calcium oxide powder). Chemical processes are carried out by shredding and grinding the chemical with waste. Chemical processes are applied more often in the disposal of cutting and piercing instruments, blood and body fluids. Chemical processes include disinfection protocols rather than sterilization methods for the disposal of medical wastes. While chemical disinfectants are used in medical activities and are used in disinfection of medical equipment, medical waste disinfection has also started to be used recently. Chemical disinfection means the destruction of pathogenic microorganisms in medical equipment or medical wastes and the removal of material or waste from pests. Chemical disinfection can be applied in liquid wastes and used in laboratory auto-analyser outputs and hospital wastewater treatment systems. The neutralization process applied to laboratory auto-analyser outputs lacks the treatment capabilities applied in wastewater treatment systems. Chemical disinfection eliminates the harmfulness of waste materials and eliminates pathogenicity. Chemical disinfectants are used in health institutions to prevent instrument disinfection in disinfection of temperature sensitive instruments and medical equipment. The chemical disinfectants used in material disinfection in health care facilities are: Quaternary ammonium compounds, ethylene oxide, glutaraldehyde, sodium hypochlorite, chlorine dioxide, hydrogen peroxide, iodophors, phenolic and formaldehyde [10].

Irradiation Technologies

Irradiation technologies in the treatment of medical waste; This standard covers designs using Electron Ray, Cobalt-60 or ultraviolet sources. Since these technologies are realized by electromagnetic radiation, they require a high level of protection against high occupational risks during use. The effectiveness of pathogen destruction depends on the dose absorbed by the waste mass. Electron rays are enough to penetrate strong waste bags and containers. Germicidal ultraviolet radiation is effective in the destruction of airborne microorganisms, but this does not apply to closed waste bags. In our country, ultraviolet technology is also used in operating rooms and intensive care units. It is a multi-purpose method used especially in neonatal and paediatric intensive care units. Its use should be carried out by personnel who are informed of the risks [10].

Biologic processes

These processes are practices that are naturally occurring in living organisms and are imitated by the degradation of organic substances. Some biological treatment systems use digestive enzymes to accelerate the destruction of pathogens containing organic waste. It has been used successfully in the separation of organic and pathological wastes by biological processes through compost and vermiculture (digestive worms) applied to pathological wastes such as organic digestible wastes and placenta. Burial method is another method used for natural waste disposal. In Turkey, legislation on the use of foetal and body parts for the disposal of capsules should be updated and unity of practice should be ensured [1,10].

Mechanical processes

It is used as an auxiliary process in the disposal of medical wastes. Mechanical processes include grinding, mixing and shredding with compression technologies. Pathogens are not destroyed, but the amount of waste can be reduced. In most cases, mechanical processes alone are not enough, but they help in the disposal of waste. It can render waste unrecognizable in medical waste disposal by mechanical processes and can be used to destroy punctures such as syringes. It is used to increase heat dissipation and penetration in increasing the effectiveness of thermal or chemical processes. Maintenance of waste management is very important in terms of being safe and effective. Grinders,

mixers and other mechanical devices are an integral part of a closed purification system. It should be used after disinfection [1,10].

Sterilization Methods for Infectious Wastes

The vast majority of medical waste from health facilities is potentially infectious. Sterilization and disinfection is one of the most established waste disposal technologies. Disinfection can be defined as minimizing the possibility of infection or the destruction of microorganisms (pathogens) that cause the disease. Sterilization is defined as the destruction of all microbiological life in the environment. Since all microorganisms are difficult to completely eradicate, the reduction in sterilization of medical and surgical instruments is often expressed as a reduction of 6 log10. (A 99.9999% reduction). With the STAATT classification system, it refers to the disinfection or sterilization efficiency corresponding to the probability of survival of one million (0.000001) of the total microorganisms. The treatment levels defined for microorganisms are as follows [1,10] :

- Stage I: 6 log 10 reduction in plant bacteria, fungi and lipophilic virus inactivation
- Stage II: 6 log10 reduction vegetative bacteria or less fungi, hydrophilic / lipophilic viruses, parasites and mycobacteria inactivation;
- Stage III: 6 log 10 reduction or inactivation of parasites and mycobacteria for plant bacteria, fungi, hydrophilic / lipophilic viruses and 4 log 10 reduction Inactivation of *Geobacillus stearothermophilus* spores and *Bacillus atrophaeus* spores;
- Stage IV: 6 log 10 reduction of inactivation of plant bacteria, fungi, hydrophilic / lipophilic viruses, parasites, mycobacteria and *Geobacillus stearothermophilus* spores.

A common microbial inactivation standard, Level III, has been proposed for medical waste disposal based on the STAATT criteria. Some other applications are: Steam Treatment Technologies, Pressure Steam Sterilization, Integrated Steam Based Treatment Systems, Wet and Dry Heat Treatment, Wet Thermal Treatment, Dry Thermal Method, Microwave Treatment Technologies and Chemical Treatment Technologies.

Combustion

Combustion is an exothermic chemical oxidation process. It is the elimination of wastes that cannot be reprocessed and rendered usable and which are not disposed of in storage areas by using dry oxidation. Medical waste incineration occurs at high temperatures. Heat treatments occur at temperatures between 1000 ° C and about 2000 ° C. Incineration should be carried out at temperatures between 1150 and 1300 ° C for 1-3 seconds in order to prevent dioxin and furan formation in the disposal and disposal of medical waste. It includes combustion, pyrolysis or gasification processes. Combustion is a process that must be continuously monitored because many harmful chemicals are produced as a result of combustion [11]. When designing combustion plants, central planning should be made due to high installation and operating costs [12]. Combustion systems require control and treatment processes due to the atmospheric pollutants it contains.

Combustion Plant [3], despite the appropriate waiting time, there is a risk of emission of exhaust gases into the atmosphere, especially when chlorinated plastics are burned [11]. The principles to be followed in the incineration of medical wastes shall be carried out in accordance with the provisions of the regulation on the control of medical wastes and the relevant articles of the regulation on the control of hazardous wastes. If large amounts of genotoxic waste are present in the waste to be incinerated, the temperature must be at least 1100 ° C [4].

Double Chamber Combustion Furnace (Air Controlled Combustion)

It is also called Prolific incinerator. It is a preferred method of disposal of medical waste. Incineration is performed in two or more cells for waste incineration at both low and high stoichiometric oxygen levels. Generally, these furnaces consist of a front combustion chamber and a final combustion chamber. Wastes are firstly burned in the pre-combustion chamber at an average temperature with a low oxygen content by using additional fuel and ashes result in ashes and gases. Gases from the pre-combustion chamber are burned in the final combustion chamber, where oxygen and temperature are higher. The pre-combustion chamber temperature is 800-900 °C, while the final combustion chamber temperature is between 900-1200 °C. Smoke and gases from the final combustion chamber are reduced to a minimum.

In double-chamber combustion furnaces, the additional fuel burner is used to raise gas temperatures and ensure complete combustion. The control of the temperatures is controlled by the air level adjuster in the burner. The use of low air levels in the first chamber allows the flue gas to be very low particulate and to filter the materials. The particle level in multi-cell burners is higher (7 pounds / ton) compared to air-controlled units (1.4 pounds / ton). Dual chamber combustion furnaces are more advantageous because additional control devices are required to retain smaller particles. It is suitable for the disposal of all medical wastes from health institutions. The calorific values of wastes should exceed 3500 kcal / kg (14650 kJ / kg). Wastes that should not be burned in these furnaces are radioactive wastes, pressurized containers, halogenated plastics such as PVC, heavy-metal wastes (eg lead, cadmium, mercury) and genotoxic wastes. The combustion temperature in these furnaces is between 900-1200 ° C. Incineration capacity varies between 200 kg / day and 10 tons / day [13].

Rotary Furnace Combustion Plants

The combustion process is two-stage. The first stage consists of a cylindrical rotary kiln laying with a firebrick at an angle of 3 to 5 degrees to the horizontal. The second stage consists of a combustion chamber designed to burn combustion gases consisting of a rotary kiln designed to withstand high temperatures. They are preferred for the disposal of chemical wastes. The rotary kiln is designed at an angle of 3 to 5 percent around the horizontal axis, allowing the waste to be attracted through the rotary kiln. Gases released as a result of combustion are destroyed by burning at high temperature in the combustion chamber. The residence time of the waste in this furnace is around 2 seconds. The waste flow rate is a function of the speed of the furnace, which can vary [3]. The flue gas emission values generated as a result of combustion must comply with national standards. The flue gases of combustion furnaces are ashes, heavy metals, dioxins, furans, thermally stable organic compounds and so on. nitrogen oxides, sulphur, carbon and hydrogen halogens.

Pyrolysis and Melting: Gasification of wastes with high temperature is a process of high mass and volume reduction [14].

Landfill

In cases where there is no or no pre-treatment for the disposal of medical wastes, medical wastes should be stored in regular storage areas in order to isolate the harmful effects. The main risk of burying medical wastes in landfills is that the risks to living things have not been terminated [3]. (WHO, 1999). In all waste systems, land access is required for waste reduction or final disposal of medical waste remaining after pre-treatment. No matter which disposal system is used, the final product must be stored. There are two different types of disposal in the land disposal system: Landfill methods for medical waste are preferred where land is suitable. Methane and hydrogen sulphide gases emerge due to decomposition of organic materials in a landfill [15].

Developing Technologies

The most commonly discussed technologies in the literature include plasma, pyrolysis, superheated steam, ozone and promession. Plasma arc torches or electrodes are used to pyrolysis wastes with very little air at elevated temperatures of several thousand degrees using electrodes.

Another developing technology uses heated steam at 500 °C. It is preferred for disposal of infectious, hazardous chemical or pharmaceutical wastes. The vapours are then heated in the steam reforming chamber to 1500 °C. These technologies, such as incineration, are expensive and require pollution control.

Ozone (O_3) can also be used to disinfect waste. Ozone gas readily separates oxygen (O_2), a strong oxidizer and a more stable form. Ozone systems require grinders and mixers to produce bactericidal waste.

Ozone was used for water treatment and air purification. At concentrations greater than 0.1 ppm, ozone may cause eye, nose and respiratory tract irritation As with other chemical treatment technologies, it must be checked with microbial regular tests that meet inactivation standards.

Promession is a new technology that combines heat raising and mechanical process in anatomical waste disposal. New technologies for hazardous chemical waste disposal; gas phase chemical reduction,

base catalysed decomposition, supercritical water oxidation, sodium reduction, vitrification, mechanical chemical treatment, sonic technology, electrochemical technologies and phyto-technology [1,10].

Disposal Examples in Some Countries

Improper disposal of waste poses a high risk of disease transmission among health workers, waste workers and the general public. In India, medical waste is usually collected in cardboard boxes and incinerated in small incinerators. In one study in Ukraine, recycling facilities recycle plastic syringe parts by re-melting. It melts the needle sections in the foundry. Mechanical needle cutters steam sterilization process is applied to the plastic parts separated in the current autoclave [23]. Similarly, in a pilot study by the Swiss Red Cross in Kyrgyzstan, needle cutters were used. The syringes and needles in the autoclave were separated and shredded by the locally made hammer mill shredder and the plastics were grated. The plastic sold was re-melted and used by the plastic manufacturer to make plastic parts cloakroom, flower pots and other commodities [16,1,10].

MATERIAL METHOD

In order to collect the necessary data for the mass characterization of wastes originating from health institutions, researches were conducted in City State Hospital and Our University Faculty of Medicine Hospital. The medical waste composition was determined by on-site assessments and consultations at City State Hospital. The necessary safety measures were taken under the supervision of the personnel in charge of the service waste bags in order to determine what kind of wastes come out from which services.

University Medicine Faculty Hospital environmental management unit in cooperation with the last 5 years of medical waste production quantities of the hospital has been determined. In order to determine the bedside production amounts of the wastes produced, the number of beds and bed occupancy rates were determined by examining the change in the number of beds of the hospital.

Determination of Medical Waste Production Phase

As a result of the researches, it has been determined that the amount of medical waste production in hospitals varies on a unit basis. Since it has an effect on the amount of medical waste production, waste production on the basis of service was determined in the hospital. Wastes accepted to the medical waste depot with labels indicating which service was produced and on which date were produced, and waste production information per service was created. The amount of waste produced per bed was determined on a service basis by dividing service occupancy rates by the number of reflected service beds. In addition, by determining the rate of service per bed and hospital medical waste production rates (bed / day / kg), the waste production phase is determined by dividing the amount of service produced per service into average production throughout the hospital. Waste production phase; o the velocity coefficient or acceleration of the unit or service affecting the overall rate of medical waste production. In the in-unit waste management plan, it is determined from which service the unit of medical waste production is the most in the facilities with medical waste production phase and how much waste minimization in this unit will decrease the production of medical waste. When comparing the amount of medical waste from hospitals, the bed occupancy rates should be differentiated according to the total number of beds and the result should be divided into total medical waste production. Since the production of bedside medical waste determines the general production, the use of more waste production phases in medical waste minimization is a guide for solving the problem at its source.

Investigation of Medical Waste Production Status in Turkey

One of the highlights of the results obtained in the 2013 survey, which includes the amount of medical waste produced in 2012 by the Public Hospitals Institution and 87 affiliated provincial secretariat hospitals in Turkey, differs from the provinces such as countries.

RESULTS AND DISCUSSION

Mass Characterization of Medical Wastes

Wastes from activities in health facilities are generally variable in quantity and character. Waste characteristics should be determined according to the services in hospitals. Wastes from health

institutions are generally domestic, infected and penetrating waste. Infected wastes are mostly produced in operating theatres and intensive care units [17].

In hospitals where waste segregation is not done properly, the amount of infected waste increases. In the absence of waste segregation, all wastes are considered to be infected [18].

Factors such as the bed capacity of health care institutions, the variety of treatment methods applied, the numerical effectiveness of the methods used for diagnosis, the number of Class A surgeries are directly effective in the production of medical waste. In order to determine the bedside production of the wastes coming out of hospitals, the preference of the disposal system and the given data should be determined correctly [19].

The wastes produced in health institutions are very variable in content. General wastes are mostly; cardboard, wood, glass, cardboard, plastic, paper, metal, food waste, textile waste and garden waste. In general, the number of inpatients and the physical conditions of the hospital are effective. In addition, infected, penetrating, pathological and radioactive wastes are produced from hospitals. Although production amounts are around 15-20 percent of total waste, disposal and collection are hazardous wastes requiring special methods.

A study was carried out at Bilecik State Hospital to identify wastes from hospitals and wastes were identified. Since service-based wastes have similar characteristics in all hospitals, they serve as an example for wastes from other hospitals. State Hospital, there are waste types from the services.

a. Paper, cardboard, cardboard, various types of packaging, non-penetrating glass, plastics, food waste, metal and metal alloy materials, textile waste and so on. materials covered by general waste.

b. Intravenous catheter, urine catheter, bladder, aspiration catheter, nasal cannula, nasal mask, blood bag, blood set, syringe, serum set, protective gloves, protective mask, blood, all other substances that come into contact with blood products and body fluid dressing wastes, etc. contaminated materials with infected character.

c. Lancet, broken glass and glass products, scalpel, syringe needle, other needle cutters, orthopaedic nails, suture wires, etc. materials having the quality of stinging, puncturing and disrupting the integrity of the leather,

d. Battery, pharmaceutical waste, cartridge, toner, fluorescent bulb, mercury materials, etc. flammable, explosive, carcinogenic, oxidizing, corrosive, etc., materials with dangerous character.

e. Plesenta, Human limbs, Leucotomy, Pneumonectomy, Appendectomy, *etc*. organ and organ parts removed by surgical operations, tissue and organ parts after autopsy and amputation, tissue and organ parts obtained by biopsy.

f. All kinds of hazardous wastes, such as high-level disinfectants, formaldehyde, xylene, xylene alcohol, genotoxic, chemotherapeutic, cytotoxic, pharmaceutical wastes that are directly harmful to human health or capable of degrading the quality of the receiving environment.

Although the composition of waste produced varies, most of the wastes from health institutions are domestic wastes. Domestic wastes do not require additional measures since they are collected in masses of 5 to 7 times the mass of medical wastes, since they are not transported or disposed of. Other hospital wastes are generally hazardous wastes. Their collection, transport and disposal are subject to special processing. The measures have to start from the source and continue until they are eliminated.

Infectious wastes generally have the same content as household wastes in terms of their content as well as their infected character. In some countries in the world, they are sterilized in hospitals and subjected to the same protocols as domestic waste. Although it is difficult to follow and control, it is certain that it will be more advantageous economically. The general content of hospital wastes is given below.

When the composition of hospital wastes is examined, it is observed that the proportion of paper and plastic in general waste production is high. Especially in services such as intensive care and operating rooms where the production of infected waste is observed intensely, the 90% paper and plastic content provides advantage to the incineration technology for medical waste. Calorific value and moisture content is as important as the content in combustion technology.

In our country, chemotherapy wastes are subjected to incineration from infected wastes, which also represent dangerous wastes, while other infected wastes are not recycled. In other countries, especially the injectors from infected wastes are separated from their needles and the plastic parts are recycled and the production of household items, including flower pots and ornaments, is applied in today's world.

The packaging of medical equipment used in hospitals is collected separately with infected wastes, while the amount of infected waste is reduced and economic gains can be achieved within the scope of recycling. Although the solution containers used in dialysis services are within the scope of hazardous waste, they should be given to licensed recycling companies.

The chemical composition of medical wastes is about 37% carbon, 18% oxygen and 4.6% hydrogen. During combustion, toxic metals easily spread to the atmosphere lead, mercury, cadmium, arsenic, chromium and zinc are formed [20]. As it can be seen from the table, medical wastes can be used as secondary fuels even if they have emission and economic sustainability.

Production Amount of Medical Wastes

The total amount of medical wastes produced daily from health institutions is directly proportional to the number of beds. The amount produced per bed depends on various factors such as waste management methods of health facilities, branch or general hospital and daily hospitalization. Bedside production from health care facilities varies between two hospitals of the same status as the difference from country to country.

Development levels of the country affect the amount of waste produced per bed. In low-income and middle-income countries, the generation of bedside medical waste is generally lower than in high-income countries. Located in the same status two hospitals in Turkey and the United States should be expected to rise proportionally high compared to hospitals in the United States. Because the development of hospitals is different, the disposable substance rates used and the disposal fees they pay for the disposal of medical waste are compared to the hospital budget and the results will be seen to be proportional to the development [7].

When comparing hospital waste generation, total mass and bedside should be compared separately on a daily basis. The ratio between the parameters should be taken into consideration for objective evaluation. When comparing the facilities that perform successful waste management, the number of large operations performed in the operating room and the production scale per full bed in intensive care units should be evaluated. Even if total waste production does not change, waste compositions and amount of hazardous waste to be produced will be reduced if correct waste separation is made at source. In this way, environmental impacts resulting from medical and hazardous waste disposal will be reduced and economic obligations will be eliminated.

One of the issues affecting the production of waste in operating theatres is the number of group A cases that occur in the operating room. In hospitals with a high number of cases, the increase in the mass of medical waste is almost certain. Because the waste production phases of the operating room and intensive care are high. The waste generation phase is calculated on the basis of the daily waste generation per full bed. Group A surgeries increase bed occupancy rates. The units that contribute to the amount of bedside medical waste in health institutions are intensive care and operation rooms. However, this applies to cases where medical waste management exists and is performed by professionals. Medical waste generation in non-professional waste management leads to an increase in the percentage of total waste production.

The area of activity, capacity and occupancy rates of the health institution affect the production of medical waste. It shows the mass production mass indexes based on the number of beds.

As the number of diagnosis and treatment to be made in facilities with high technological infrastructure will increase, the amount of medical waste production increases. The technological infrastructure of health institutions and the impact of their activity areas on the production of medical waste.

Waste statistics survey of health institutions; It is applied in health institutions (university hospitals and clinics, general purpose hospitals and clinics, maternity hospitals and clinics, and military hospitals and clinics) that produce large amounts of waste in Annex-1 of the Regulation on Control of Medical Wastes. The aim of the study is to determine the amount of medical waste consisting of infectious, pathological and cutting-penetrating wastes [21].

CONCLUSION AND SUGGESTIONS

Medical waste management in our country has become more important in recent years due to the increase in disposal costs. It has gained importance in legal and economic factors as well as environmental and ecological factors in medical waste management. The most important issue in

sustainable medical waste management is the establishment of a national medical waste management policy. One of the compulsory issues to be included in the waste management policy to be created is the guide that includes medical waste definitions in accordance with the realities of our country. In practice, the guide has the potential to provide benefits in many aspects ranging from waste minimization, planning of disposal facilities to financial burden on health facilities, which can answer questions that arise in the field on the definitions. Many countries have technical guidelines that solve or mitigate problems encountered in practice. The stage after the definitions is the applicability of the identified definitions. The application directly affects the potential for results. Implementation success is subject to a measurement and evaluation process. The efficiency of the applications realized in the light of the definitions will be reached through the calculations of waste generation per bed kg. Considering the medical waste production phases in bedside calculations will provide access to realistic data in evaluating the success of both waste minimization and waste management.

Thanks to the multidisciplinary system to be applied in medical waste management, the amount of waste produced will be reduced while the amount of material to be disposed of will be reduced. This process will end the environmental impact and product flow as well as the financial benefits it provides. Medical waste management process is a system which has been understood by our country in recent years and tried to find solutions. In our country, medical waste disposal is carried out by sterilization and incineration methods. Cost pressure of disposal methods necessitates medical waste management. The success of waste management by health institutions has to be monitored by kg / bed waste production. Considering the capacity utilization rates in health facilities producing high amounts of waste, the amount of waste produced should be determined. The amounts that similar health facilities will achieve in successful waste management should be similar. In the correlation to be made between similar health facilities, it is important to calculate the amount of waste that can be generated on the scale of the number of bed days of operating room and intensive care patients in terms of safe waste management. Waste management and financing are important as medical waste is hazardous waste. In the trainings to be carried out in relation to these processes, the principles of waste minimization and the following issues regarding the application should be mentioned.

In-unit waste management plan should be prepared to minimize medical waste. The plan should specify the services from which medical wastes will be collected and at what times. What kind of wastes emerge from which units should be determined according to the type of waste? Medical waste collection vehicles should be orange in accordance with the provisions of the regulation on medical waste control. Personnel collecting medical waste should wear special clothing and PPE. Contamination should be prevented within the framework of waste minimization and non-infected wastes should be separated at source and medical waste production amounts should be reduced. The number and location of medical waste collection containers should be selected in a certain systematic way and should not be available in patient rooms. The waste production per service should be determined by writing the name of each service on medical waste bags. Packaging waste, household waste and medical waste collection containers should not be in the same place, if possible. Wastes not infected and contamination risk should be evaluated in the category of domestic waste by working together with infection committees. The amount of waste produced in hospital automation should be entered and services that increase monthly waste production should be controlled. Procurement protocols to reduce waste generation should be established. For example, glass serum vials should not be taken unless required. Drug preparation rooms should be available in the isolation boxing and instance services, and there should be no medical waste collection containers in these rooms. Medical waste collection containers should not be provided in chemotherapy units. Wastes should be considered within the scope of cytotoxic waste. Medical waste collection containers should not be provided in the pathology laboratory. Formaldehyde tissue and organ parts should be treated as contaminated hazardous waste.

Waste management is a dynamic process due to its content. All effective matters in the process must be under constant control and supervision. Audits and controls should be carried out within the framework of objective criteria. The success of the health facilities in waste management can be calculated by calculating the phases and quantities of waste produced per bed. For several effective medical waste management program, the number of beds and the occupancy rate for each medical facility should be available.

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