

Short Communication

Medical Waste Management in Poland – the Legal Issues

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Abstract

This paper discusses the issue of medical waste, which is highly significant from the perspective of environmental protection. It describes the waste classification criteria, the methods of its collection, and neutralization. They are based on the legislation, including above all the Waste Act of 27 April 2001. The priority goal of the Act is to ensure that human health and life are protected. The Act was drawn up as a transposition of European directives. Analyzing the current legislation in force, the paper notes that the Polish legislature in the amendment to the Act of 2005 allowed medical infectious waste, posing an epidemiological threat, to be neutralized exclusively by means of incineration, excluding the possibility of using alternative methods. Thus the legislature expressed the view that only this method, despite its numerous disadvantages, is the most appropriate one for biohazardous waste. Moreover, due to the new provision of the Act, the expenses borne by hospitals to set up the infrastructure for alternative neutralization methods have proved to be unnecessary investments. The appropriate supervision over infectious medical waste management from the perspective of environmental protection, epidemiology, and occupational safety is a vital element in the development of a medical waste management system, but economic factors also should be taken into account.

Keywords: medical waste management, environmental safety, infectious waste, incineration, legislation

Introduction

Waste is classified according to its origin. Pursuant to the Polish legal definition found in the Waste Act of 27 April 2001 [1], medical waste is defined as waste originating in connection with the provision of health care services and the conduct of scientific research and experiments in the field of medicine. It should be noted that this definition is ambiguous and suggests that blood, human secretions, and used medical equipment may be classified as medical waste. Medical waste may come from health care facilities,

i.e. hospitals, hospices, residential homes, nursing, therapeutic-and-educational and nursing-and-therapeutic institutions, and outpatient health care centers. The definition of medical waste in the act omits medical waste generated at home.

Medical waste, pursuant to the regulation of the Minister of Health dated 30 July 2010 on the detailed procedure of medical waste management [2], is divided into three groups. The first one includes infectious waste, i.e. hazardous waste containing living microorganisms or their toxins and other forms capable of transmitting genetic material that are known or can reliably be assumed to cause infectious diseases in humans or other living organisms.

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The second group includes special waste, namely hazardous waste containing chemicals that are known or can reliably be believed to cause non-infectious diseases in humans or other living organisms or to be the source of environmental pollution. The third group is other waste, which has no hazardous properties. According to the legislative principles, medical waste generated during the provision of health care services at health care units and entities conducting scientific research and experiments in the field of medicine is collected selectively, separating infectious, special, and other wastes. Infectious and special waste is collected in accordance with the relevant neutralization methods, while other waste is handled in the way specified for municipal waste.

Medical waste poses a particular hazard for the environment due to the possibility of the pathogens and microorganisms it contains coming into contact with the environment, and because of the presence of expired or only partly used therapeutic products capable of having a toxic effect [3, 4]. The priority in its neutralization is effective prevention of the biological and epidemiological hazards they may cause, while observing the standards of environmental protection and safety [5, 6].

Polish law provides for medical waste neutralization, at the same time prohibiting the recovery of some categories of such waste [7]:

- waste from medical diagnostic, treatment and preventive procedures:
 - a) body parts and organs and containers for blood and preservatives used for its storage
 - b) other waste containing living pathogenic microorganisms or their toxins and other forms capable of transmitting the genetic material that are known or can reliably be believed to cause diseases in humans and animals
 - c) chemicals, including chemical reagents, containing hazardous substances
 - d) cytotoxic and cytostatic medications
 - e) dental amalgam waste
 - f) used biologically active therapeutic baths with infectious properties
 - g) remains of food provided to patients at infectious diseases wards.

The epidemiological hazards of medical waste can be eliminated by incineration. This method permits a considerable reduction in the volume and bulk of incinerated waste. At the same time, it results in emissions of toxic combustion gases that contain dibenzodioxins, dibenzofurans, polychlorinated biphenyls, polycyclic aromatic carbohydrates, carbon, cadmium and lead oxide, and steams of lead, arsenic, hydrochloride, hydrogen cyanide and nitric oxides [8, 9]. Hence, it necessitates the use of expensive systems for the reduction of these substances. The use of closed incineration chambers fitted with exhaust analyzers, proper filters, or sorbents that ensure the minimum level of harmful substances emitted with exhaust gases to the atmosphere, raises the costs of the process. Moreover, the necessity arises to manage such remains as: ash from incineration chambers, filtered volatile ash, saturated sorbents and channeled technological waste. Another disadvantage

of incineration is the harmfulness of ash which, being a secondary waste, contains hazardous substances but no pathological microorganisms [10, 11]. The management of the remains of hospital waste incineration is one of the fundamental problems relating to its processing. Specific community regulations on waste incineration are included in the European Parliament and Council Directive 2000/76/EC of 4 December 2000 [12].

There are neutralization methods alternative to the incineration processes of medical waste (Table 1). One of them uses microwaves in the processing of waste. This technology makes it possible to obtain unidentifiable, microbiologically sterile remnants. As regards environmental nuisance, microwave installations are strong competition for incineration plants since they do not burden the environment with harmful incineration products [13]. Such installations can operate on a stationary or mobile basis. The effectiveness of the process is conditional upon proper shredding/maceration of waste and duration of the process. The waste introduced into the feeder is humidified and air saturated with hot steam is removed by a filtration system. The process time and temperature are subject to monitoring. The methods based on microwave radiation are not used on a wide scale nowadays.

Another method, frequently used and effective in reducing the microbiological load, is autoclaving, which guarantees the destruction of pathogens. The effectiveness of the process is controlled by means of bioindicators [14]. Autoclaving that incorporates an internal shredding device is highly practical and economical. Due to the shredding process, microwaves, and steam, steam gains easier access to the material and the volume of waste is reduced. Volume reduction is an important factor limiting the amount of medical waste, which is usually light but bulky. The remnants of the process are pellets [15]. The most frequently used autoclaves are vacuum and gravity autoclaves of various sizes that can be used both in small doctor's or dentist's surgeries and large hospitals. In a vacuum autoclave, air is removed from the chamber before introducing water vapor, while in a gravity autoclave air is displaced by water vapor. Thermal disinfection, conducted in specially adapted installations and appliances, also allows getting rid of waste's infectious properties. In the process, waste is initially shredded and heated. The treatment chamber contains a hollow Archimedes screw filled with hot oil. The outer "jacket" of the chamber also contains hot oil. The remaining secondary fall is concentrated and the exhaust gas is filtered. There are installations where the end product is a sterile smooth plastic disc that can have a practical application [16]. Physicochemical processing methods are used too.

Chemical methods mostly based on compounds containing chloride or peracetic acid are used in modern appliances where toxic chemicals used in the process are resolved or diluted to acceptable concentrations pursuant to relevant regulations. The problem is non-existent when methods based on hydrogen and ozone peroxide are used. The neutralization process can also be performed using a combination of methods.

Table 1. Comparison of alternative methods for medical waste neutralization.

Neutralization method	Advantages	Disadvantages
Incineration	<ul style="list-style-type: none"> - high reduction of waste mass - low costs of waste storage following incineration - highly effective sterilization of incinerated material 	<ul style="list-style-type: none"> - high costs - high emission of fumes - significant environmental impact because of gas, solid and fluid products of incineration - presence of plastics in waste contributes to the emission of heavy metals - highly expensive fume treatment system - wastage of recyclables (paper, glass, metal) - secondary process waste (from filters, treatment appliances, cinders, sludge) is considered hazardous and must be neutralized
Microwaves	<ul style="list-style-type: none"> - simplicity of the method and low unit cost of the process - no emission of hazardous substances - possibility of installation in a mobile system - the remains qualify as municipal waste 	<ul style="list-style-type: none"> - no reduction of waste mass - cannot be used for liquid blood and hazardous chemicals
Autoclaving	<ul style="list-style-type: none"> - simplicity of the method, ease of operation and low unit cost of the process - no emission of hazardous substances - possibility of processing glass, metal objects - possibility of installation in a mobile system - possibility of adjusting the size of the appliance to the amount of waste produced, and of working on a continuous and intermittent basis - the remains qualify as municipal waste 	<ul style="list-style-type: none"> - no reduction of waste mass - cannot be used for: thermolabile objects, radioactive substances, cytostatics, explosives, flammable fluids (alcohol, ether, solvents), human remains - smell (the odor is neutralized by means of special filters)
Thermal disinfection	<ul style="list-style-type: none"> - simplicity of the method and low unit cost of the process - possibility of processing such materials as glass and large metal objects - possibility of installation in a mobile system - the remains qualify as municipal waste 	<ul style="list-style-type: none"> - reduction of waste mass by approximately 20% - cannot be used for: radioactive substances, cytostatics explosives, flammable fluids (alcohol, ether)

Relative to the safety of the treated waste, it is possible to state that using both incineration and alternative methods provides an end product that is sterile. The sterility of medical waste obtained by means of methods alternative to incineration is guaranteed by observing the proper mode of handling materials before the process (packing), correctly running the process itself and its monitoring and careful handling of the material after the process, and during storage and transport. To ensure their effectiveness, appliances or installations are equipped with computerized systems for continuous recording of process parameters; they are validated and controlled for the quality of sterilization (using chemicals or bio-indicators). Thus, it is possible to state that the above-described alternative methods are equivalent in terms of their microbial inactivation effectiveness, i.e. the removal of all the forms of microorganisms. Alternative methods require prior thorough segregation and shredding of waste, which can lead to an increased epidemiological risk due to the human factor. On the other hand, this necessitates taking preventative measures aimed at streamlining waste management and reducing its amount.

In economic terms, the advantage of alternative methods is the availability of appliances to both individual

health care establishments and companies specializing in infectious medical waste neutralization. In contrast to incinerating plants, both continuous and temporary use is equally efficient. Alternative methods are easy to operate. Using alternative methods offers a possibility of savings. In alternative methods, investment and operating costs are lower. For comparison, the cost of neutralizing 1 kg of infectious waste by means of incineration varies between PLN 4.50 and 2.25, depending on the province. The final price is also affected by transport costs. The cost of autoclaving 1 kg of infectious waste oscillates around PLN 1.70 [16]. In addition, the lower costs of alternative methods result from the possibility of processing waste on the spot.

Considering the environmental impact, alternative methods, as compared to incineration, are safer and they do not contribute to the emission of hazardous substances. The waste remaining after the process has the properties of municipal waste. Alternative methods, however, do not ensure the reduction of waste mass, which is the case in incineration, thus occupying more space at waste storage yards. Moreover, they do not offer the possibility of neutralizing hazardous waste (e.g. medications) or eliminating harmful and toxic ingredients.

The view of WHO on medical waste neutralization formulated in the strategic document "Safe healthcare waste management" from 2004 seems to point to the promotion of the trend toward using alternative methods: "Efficient and increased promotion of non-incineration technologies aimed at the final neutralization of medical waste in order to prevent diseases caused by: (a) inappropriate medical waste management and (b) exposure to dioxins and furans."

Alternative methods cannot be used for every type of medical waste – therefore, it is necessary to choose the right method [17]. It seems, however, that the role of legislation in the present situation should not be to impose a particular handling procedure but to give the concerned parties the possibility of choice. The present situation does not encourage hospitals to seek an alternative to incineration and implement a consistent and rational waste management system. While choosing the method, it is necessary to take into account the origin, weight and manner of storage and transport on the premises of the hospital or another health care facility. The next step should be the introduction of a system of control and segregation into categories appropriate to the specific method. In Germany, consistent waste segregation resulted in a 10-fold reduction in the quantity of waste over 6 years [18].

Polish law provides for ways of medical waste neutralization, as set out in the regulation of the Minister of Health dated 23 December 2002 on the acceptable ways and conditions of neutralization of medical and veterinary waste [19]. They include, but are not limited to, thermal transformation of waste in installations or units located on land. The thermal waste transformation process is conducted in such a way that the temperature of gases forming as a result of incineration upon the last supply of air, even under the most unfavorable conditions, has been maintained for at least 2 seconds at 1,100°C minimum. The temperature is measured near the inner wall or another representative spot of the combustion or exhaust heat chamber, according to the technical specification of the installation. Throughout the process, the temperature is continually measured in the combustion chamber near its inner wall in such a way as to eliminate the influence of thermal radiation of the flame and oxygen content in the exhaust gases as well as the pressure of the exhaust gases. Equipment for continual measurement of process parameters is utilized to perform the required measurements and it must be subjected to annual technical inspections and calibrated at least every 3 years. Thermal neutralization of waste is intended to eventually ensure the appropriate level of its transformation, expressed as a maximum content of non-oxidized organic compounds, the measure of which can be:

- 1) the total content of organic carbon in furnace cinders and ashes not exceeding 3% or
- 2) the share of combustible components in furnace cinders and ashes not exceeding 5%

...determined according to the Polish Standards.

The regulation also provides for a possibility of utilizing alternative neutralization methods such as: autoclaving, thermal disinfection, microwave treatment, and other physicochemical processing. The condition for their uti-

lization is, according to the Polish standards, obtaining a positive opinion for each equipment type, issued by the chief sanitary inspector or the entity appointed by him or her.

The handling principles for medical waste are specifically defined by the regulation of the Minister of Health of 30 July 2010 [2]. The regulation states that medical waste should be collected at its place of origin, taking into consideration their properties and method of neutralization or recovery. Waste should be disposed of by persons providing health care services, taking the adequate precautions, and immediately transferred to the room or equipment for medical waste storage. Waste should be collected in special containers or bags, which are to be filled up to 2/3 of their capacity in such a way that they can be safely closed. It is unacceptable to open containers or disposable bags that have been closed. Containers must be replaced at least every 72 hours. Every container and every bag with medical waste should have visible identification labels, including the code of the waste they contain, the address of residence or registered office of the waste producer, and closing date. Internal transport of medical waste from its place of origin to the storage, neutralization, or collection site may be carried out using the means of transport intended exclusively for this purpose. Transport must be organized in such a way as to prevent direct contact with waste. The medical waste storage room should have its independent entry and be protected from access by unauthorized persons. Its walls and floors must be made from smooth, easily washable and disinfectable materials and it must be protected from the access of insects, rodents, or other animals. Such rooms have separate boxes, depending on the type of medical waste collected, in accordance with its sorting principles at places of origin. It is also necessary to install a ventilation system providing negative pressure, and ensuring the filtering of removed air. It is acceptable to use gravity ventilation provided that waste is collected in tightly sealed boxes or containers, labeled in accordance with the type of medical waste stored.

Infectious Waste – Special Regulations

Infectious waste is classified as dangerous waste. The special principles governing dangerous waste management are set out in Directive 2008/98 [20]. The European Community considers it the key priority to prevent the generation of waste, including dangerous waste, in connection with the provision of health care services. Dangerous waste is defined as waste displaying at least one of the dangerous properties mentioned in Annex III to the Directive. It includes substances or preparations containing living microorganisms or their toxins that are known or can reliably be believed to cause diseases in humans or other living organisms.

The waste act in its original shape allowed for the utilization of various methods alternative to incineration, for the neutralization of infectious waste. In the present shape of the act, Art. 42 par. 1a, added in 2005, announces an absolute ban on neutralizing infectious medical waste in

other ways than by incinerating in waste incinerating plants, leading to a reduction of the total organic carbon to 5% in such waste. It is unacceptable to incinerate it in ordinary incinerating plants, e.g. those located on hospital premises or co-incinerating plants, whose main purpose is to generate energy from waste incineration. It should be added that during thermal conversion into energy medical waste is characterized by a high caloric value [21]. Neutralizing infectious medical waste in any way other than incineration in waste incinerating plants is illegal and punishable as an offence. Thus, the legislature has assumed that only incinerating can fully guarantee epidemiological safety. Such a view has no justification in community law which, although not imposing the acceptable methods of neutralization of such waste, does not exclude the possibility of using others either. The consequence of introducing the above provisions into the act is also the questioning of the legitimacy of the costs of the investments made by hospitals and other health care units, which invested in equipment for alternative neutralization procedures. This equipment can be used today but not for infectious waste. Entrepreneurs using alternative methods of medical waste neutralization have so far been competitive with companies with their own incineration plants.

During thermal transformation, infectious medical waste is placed directly in a furnace, without previously mixing it with other waste categories [19].

The incineration process must observe the European priorities with respect to ensuring a high level of environmental and human health protection. It is necessary to maintain rigorous working conditions, technical requirements, and acceptable emission levels for incineration systems. The acceptable emission levels, established by the community law [12], should prevent or limit, as far as practically possible, the negative impact on the natural environment and the resulting threats to human health. The community law sets the goal of reducing the emission of dioxins from identified sources and emissions of cadmium, mercury, and lead. As regards the quality of air, the Community's goal is to ensure effective protection of all the people against the identified health threats arising from air pollution.

The waste act establishes a ban on storage of infectious medical waste. The ban is a mandatory rule of law. Infectious waste must not be recovered either.

The Polish legislature introduced a ban on collecting medical waste outside its place of origin (the ban does not apply to medical waste generated during the provision of ordered services). Therefore, infectious medical waste generated during the provision of ordered services should be immediately delivered to the properly prepared warehouse premises intended for storing such waste. In addition, the act bans carrying infectious medical waste out of the province where it was generated or bringing medical waste from outside of the area of the province. One exception from the proximity rule is permitted if the distance between the place of generation to the neutralization installation or location planned is shorter than the distance from the installation or location situated within the same province.

Unfortunately there are no publicly available current data on the number of medical waste incinerating plants in Poland. In 2010, there were 29 plants (according to information from the Waste Management Department) with capacities in the range of 150-4100 Mg/year. They are more numerous in southern Poland, where there are more hospitals as well.

The appropriate supervision over infectious medical waste management from the perspective of environmental protection, epidemiology, and occupational safety is an important element in the development of a system of medical waste management. Of key significance for effective management is sorting waste into relevant categories at the place and time of its origin [22]. Such a procedure is to guarantee possibly the most effective conditions of its neutralization. The sorting procedures adopted at health care establishments directly affect the costs and manner of its further treatment. It is vital to instruct the staff of these establishments that if municipal waste is mixed with infectious waste, then later on in the procedure all of the collected waste must be considered biohazardous [23]. Therefore, it is important to implement adequate standards of collection, labeling, and transport. Rational management of infectious medical waste at health care establishments is expected to ensure occupational health and safety for humans and effective environmental protection.

Conclusions

In Poland, medical waste posing an epidemiological threat may only be neutralized in processes leading to the reduction of the total organic carbon content to 5% in such waste. This signifies that the only legal method of processing infectious waste in this country is incineration. The Polish legislature has thus adopted a solution which, even though not contravening European law, eliminates the possibility of using alternative methods, hence grants a monopoly for infectious waste incineration plants. At the same time, there is no data in the literature that would point to incineration as the only method of neutralizing infectious waste. It might be appropriate to recommend the inclusion of other effective and approved alternative methods to be included in the legislation, requiring the full control of the conditions of these processes and their effectiveness as with incineration. Development of waste management policies, careful waste segregation, and training programs are essential to minimizing the environmental and health impacts of any technology. Unfortunately, the present legislation does not offer the possibility of choosing between neutralization methods, hence there is no incentive to seek solutions other than incineration that are likely to improve the overall quality of the medical waste management system in Poland.

References

1. Waste Act of 27 April 2001 (consolidated text: Journal of Laws of 2010, No.185, it. 1243) [In Polish].

2. Regulation of the Minister of Health of 30 July 2010 on specific procedures of medical waste management (Journal of Laws No. 139, it. 940) [In Polish].
3. GAUTAM V., THAPAR R., SHARMA M. Biomedical waste management: Incineration vs. environmental safety, *Indian Journal of Medical Microbiology*, **28**, (3), 191, **2010**.
4. TONG A.Y.C., PEAKE B.M., BRAUND R. Disposal practices for unused medications around the world, *Environ. Int.*, **37**, (1), 292, **2011**.
5. BRONSKA K. Medical waste, 1st ed.; Forum sp. z o.o.: Poznań, pp. 10-13, **2008** [In Polish].
6. SINGH K.K., JUWARKAR A., SINGH A.K., TOMAR A. Air, Water and Soil Pollution, 1st ed.; DelhiKalyani Publ.: New Delhi, pp. 396-423, **2007**.
7. Regulation of the Minister of Health of 23 December 2002 on the types of medical and veterinary waste whose recovery is forbidden (Journal of Laws No. 8, it. 103) [In Polish].
8. JIN J., LI X., CHI Y., YAN J. Heavy metals stabilization in medical waste incinerator fly ash using alkaline assisted supercritical water technology, *Waste Manage. Res.*, **28**, (12), 1133, **2010**.
9. GUO Y., WANG W., QIAO W., WAN X., YE T., LU H. Characterization of heavy metals in fly ash from hazardous waste incinerators, *J. Univ. Sci. Technol. B.*, **28**, (1), 17, **2006**.
10. ZHAO L., ZHANG F.S., CHEN M., LIU Z., WU D.B. Typical pollutants in bottom ashes from a typical medical waste incinerator, *J. Hazard. Mater.*, **173**, (1-3), 181, **2010**.
11. VALAVANIDIS A., ILLIOPOULOS N., FIOTAKIS K., GOTSIS G. Metal leachability, heavy metals, polycyclic aromatic hydrocarbons and polychlorinated biphenyls in fly and bottom ashes of medical waste incineration facility, *Waste Manage. Res.*, **26**, (3), 247, **2008**.
12. Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (OJ L 332, 28.12.2000, pp. 91-111).
13. VERONESI P., LEONELLI C., MOSCATO U., CAPPI A., FIGURELLI O. Non-incineration microwaves assisted sterilization of medical waste, *J. Microwave Power E. E.*, **40**, (4), 211, **2007**.
14. ZHAO W., VAN DER VOET E., HUPPES G., ZHANG Y. Comparative life cycle assessments of incineration and non-incineration treatments for medical waste, *International Journal of Life Cycle Assessment*, **14**, (2), **2009**.
15. MUSZYNSKI Z. The issue of hospital waste neutralization, *Therapy*, 7, (3), 19-23, 1999 [In Polish].
16. TORLIŃSKA-MACŃKOWIAK K. Assessment of medical waste management in the health care system in Poznań, a doctoral dissertation, Poznań, 124-137, **2006** [In Polish].
17. LEE B.K., ELLENBECKER M.J., MOURE-ERSASO R. Alternatives for treatment and disposal cost reduction of regulated medical wastes, *Waste Manage.*, **24**, (2), 143, **2004**.
18. SUDER S. Classification, collection and recycling of hospital waste exemplified by German experience, in: Conference Materials, Medical Waste Neutralization and Recycling, ed. Abrys: Poznań, **1997** [In Polish].
19. Regulation of the Minister of Health of 23 December 2002 on the acceptable methods and conditions of medical and veterinary waste neutralization (Journal of Laws No. 8, it. 104 as amended) [In Polish].
20. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, pp. 3-30).
21. BUJAK J. Experimental study of the lower heating value of medical waste, *Pol. J. Environ. Stud.*, **19**, (6), 1151, **2010**.
22. ZHOU F., LIU Y., GUO H.-C., WANG L.-J. Optimal selection method of technologies of medical wastes treatment, *Environmental Science*, **27**, (6), 1252, **2006**.
23. MC DERMOTT-LEW R., FAZZINI C. Identifying the key personnel in a nurse-initiated hospital waste reduction program, *Nursing Administration Quarterly*, **34**, (4), 306, **2010**.