

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

تنظيم إدارة النفايات الطبية في التشريع الجزائري وتأثيراتها على البيئة

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Abstract:

This study aims to shed light on one of the most hazardous pollutants that has attracted significant attention from both national and international legislators, due to the damage it may inflict on public health and the environment. This pollutant is represented by medical waste, which constitutes one of the most prominent challenges facing both the environment and healthcare institutions. Consequently, healthcare institutions are required to comply with legal measures to ensure the safe management of this category of waste and to adopt methods consistent with legal frameworks and international standards, with the objective of safeguarding environmental integrity and public health. This can only be achieved through the reduction, treatment, and proper disposal of medical waste.

Accordingly, it has become imperative to establish management plans aimed at ensuring the safe handling of medical waste, alongside legal provisions that guarantee its treatment and monitoring for the purposes of prevention and risk mitigation. This is particularly important given that the efforts undertaken in waste management in Algeria remain limited, primarily due to the lack of reliance on modern technologies for the final disposal of this type of waste.

Keywords: Medical Waste, Environmental Protection, Waste Management, Public Health, Healthcare Institution.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

الملخص:

تهدف هذه الدراسة إلى تسليط الضوء على أحد الملوثات الخطيرة التي أخذت حيزا كبيرا من اهتمام المشرع الوطني والدولي، وهذا لما يمكن أن تلحقه من أضرار بالصحة العمومية والبيئة، والمتمثلة في النفايات الطبية التي تعتبر من أبرز التحديات التي تعيشها البيئة والمؤسسات الصحية، حيث أصبح لزاما على المؤسسات الصحية التقيد بالتدابير القانونية لضمان التسيير الآمن لهذا النوع من النفايات وإتباع أساليب تتماشى مع الأطر القانونية والمعايير الدولية بهدف ضمان حماية البيئة وصحة الأفراد، الذي لن يتأتى إلا عن طريق التقليل من آثار النفايات الطبية ومعالجتها والتخلص منها .

لهذا أصبح من المهم وضع مخططات تهدف للتسيير الآمن للنفايات الطبية ونصوص قانونية تضمن معالجة للنفايات الطبية ومراقبتها من أجل الوقاية منها والحد من مخاطرها، لاسيما أن المجهودات المبذولة في تسيير النفايات في الجزائر تعتبر محدودة بسبب عدم اعتماد التكنولوجيا الحديثة في التخلص النهائي لهذا النوع من النفايات.

الكلمات المفتاحية: النفايات الطبية، حماية البيئة، تسيير النفايات، الصحة، المؤسسات الاستشفائية.

Introduction:

The Earth's environment is exposed to numerous risks resulting from harmful human activities, particularly through the use of pollutants generated by industrial activities and modern technologies, as well as the hazardous substances arising there from, which cause significant degradation to the environment and its ecosystem. This has rendered environmental protection a priority for all States, prompting efforts to establish legal norms aimed at addressing and mitigating such risks.

The development witnessed globally in the healthcare sector, driven by the use of modern medical technologies, has led to a substantial increase in medical waste, which is considered more hazardous than ordinary waste due to its environmental and public health impacts, as well as its potential to generate rapidly spreading epidemics, particularly when disposed of in violation of applicable legal provisions.

Algeria, for its part, faces pollution-related challenges, particularly those arising from the activities of healthcare institutions, and, like other States, is confronted with significant issues relating to the sound management and disposal of medical waste. This is especially evident in light of the limited financial and technological resources necessary to ensure its safe treatment and final disposal in a manner that safeguards public health and

environmental integrity. Accordingly, the establishment of a medical waste management scheme has become an urgent necessity, as its disposal requires a stringent regulatory framework and binding measures compelling healthcare institutions to exercise effective control over this category of waste.

In this context, Algeria has undertaken reforms of its legal framework to keep pace with environmental challenges in the field of waste management in general, and medical waste in particular. This has been reflected through a range of dispersed legal provisions across administrative, criminal, and civil legislation, as well as specific laws relating to environmental protection, with the aim of reducing the potential environmental and public health risks associated with this category of waste.

In light of the foregoing, the research problem may be formulated as follows: What are the legal measures established by the national legislator to ensure the safe management of medical waste? And what are their impacts on the environment?

To address this problem, this research paper is structured into three sections: the first examines the concept and nature of medical waste; the second analyzes the legal regime governing medical waste management; and the third explores the environmental impacts of medical waste.

I. THE CONCEPT OF MEDICAL WASTE

Although considerable attention has been given to medical waste, its management system, and its resulting environmental impacts, there is still no unified definition of this type of waste. Numerous definitions exist that may overlap in certain aspects but differ in many others. Therefore, it is necessary to define the concept of medical waste (first) and then address its sources (second).

First: General Concepts of Medical Waste

In order to clarify the definition of medical waste, it is necessary to examine its linguistic and terminological meanings, as well as its legal definition under national legislation and other legal systems, in order to distinguish it from similar terms.

1- Linguistic definition of waste:

The term “waste” refers to the remainder of something. “Nafaya/ النفية” is what remains of a thing, and also refers to what is discarded due to its poor

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

quality¹. The term is expressed in various forms such as “nifaya/نفاية,” “nafatoh/نفاته,” and “nafawatoh/نفاوته” and “nafwatoh/نفوته” all of which revolve around the meaning of discarding something due to its lack of usefulness or poor quality. The Merriam-Webster Dictionary defines waste as: “material that is rejected or discarded by residential and animal communities.”²

2- Terminological definition of waste:

The British legal system defines waste as discarded items that are considered unwanted for human use and intended for disposal³. In another definition, waste refers to any material that no longer has any utility value; however, if part of it can be reused or recycled, it may not be classified as waste.

From a legal perspective—which is considered decisive in determining the concept of waste due to its role in defining the rights and responsibilities of holders—waste is defined as any residue resulting from production, transformation, or use processes, and more generally, any material, product, or movable asset that the owner or holder discards, intends to discard, is required to discard, or removes.⁴

3-World Health Organization definition of medical waste:

The World Health Organization defines medical waste as including all waste generated by healthcare institutions, research centers, and laboratories. It also includes waste arising from secondary or dispersed sources, such as home healthcare activities (e.g., dialysis procedures and insulin injections).⁵

The French legislator defines medical waste in the implementing regulation of the French Public Health Code; however, it refers to it as “healthcare waste.” Article R1335-1 provides that: “Healthcare waste consists of waste arising from diagnostic, monitoring, preventive, curative, or palliative activities in the fields of human and veterinary medicine.”⁶

¹Thamer Mustafa Mohammed, Legal and Security Confrontation of the Illegal Trafficking of Hazardous Materials and Waste, Dar Al-Nahda Al-Arabia, 2015, p. 118.

²Khaled Al-Sayyid Al-Metwally Mohammed, Transboundary Movement of Hazardous Waste and Its Disposal in Light of International Law Provisions, 1st ed., Dar Al-Nahda Al-Arabia, Cairo, 2005, p. 34.

³Saleh Mohammed Badr El-Din, Liability for the Transboundary Movement of Hazardous Waste in International Law, Dar Al-Nahda Al-Arabia, Cairo, p. 33.

⁴Saleh Mohammed Badr El-Din, op. cit., p. 34.

⁵World Health Organization Report, Safe Management of Healthcare Waste, Regional Office for the Eastern Mediterranean, Amman, 2006, p. 02.

⁶Article R 1335-1 du décret n-2016-1590 du 24 novembre 2016, mis en vigueur le 1er janvier 2017 qui dispose: « les déchets d'activités de soins sont les déchets issus des activités de diagnostic, de suivi et de traitement préventif, curatif ou palliatif, dans les domaines de la médecine humaine et vétérinaire. Parmi ces déchets, sont soumis aux

As for the Algerian legislator, it also adopts the term “healthcare waste” under Law No. 01-19¹. In this regard, medical waste is classified under the Basel Convention² as part of the first category of hazardous waste, which includes liquid waste such as hospital waste, pharmaceutical waste, and organic solvents³. It has also been defined in several ways, including as the collection of solid, liquid, or gaseous waste generated from various healthcare establishments, health centers, clinics, laboratories, and other medical and veterinary institutions.⁴

The national legislator defines it under Law No. 01-19, Article 3, as: “Healthcare activity waste consists of all waste resulting from examination, monitoring, preventive, curative, or therapeutic activities in the fields of human and veterinary medicine.” It is also defined in the Environmental Law, Article 89, as: “Waste is any residue resulting from production, transformation, or use processes, and more generally any material, product, or movable item that has been discarded or abandoned by its owner.”⁵

Second: Sources of Medical Waste

The sources generating medical waste are divided into primary sources and secondary sources, which will be addressed as follows:

1- Primary sources of waste:

According to Executive Decree No. 03-478⁶, these sources include:

- Public and private hospitals, related laboratories, and medical research and investigation centers;
- Anatomical dissection centers, research facilities, veterinary examination units, blood banks, and blood collection services;

dispositions de la présente section ceux qui: soit présente un risque infectieux, du fait qu'ils contiennent des micro-organismes viables ou leurs toxines, dont on sait ou dont on a de bonnes raison de croire qu'en raison de leur nature, de leur quantité ou de leur métabolisme, ils causent la maladie chez L'homme ou chez d'autre organismes vivants.

¹Law No. 01-19 of 12 December 2001 on the Management, Control and Treatment of Waste, Official Journal No. 77, issued on 12 December 2001, amended and supplemented by Law No. 25-02 of 20 February 2025, Official Journal No. 16, dated 20 February 2025.

²Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, adopted in Basel, Switzerland, 22 March 1989.

³Muammar Ratib Mohammed Abdul Hafiz, The Basel Convention and Its Role in Protecting the Environment from Hazardous Waste Pollution, Dar Al-Nahda Al-Arabia, Cairo, 2008, p. 22.

⁴Muhammad Binyan Saleh Al-Mufraji & Ziad Khalaf Aliwi Al-Jawali, Civil Liability for Medical Waste, Journal of the College of Law for Legal and Political Sciences, Kirkuk University, Vol. 1, 1432 AH–2013, No. 1, p. 134.

⁵Law No. 83-03 of 05 February 1983 on Environmental Law, Official Journal No. 06, repealed by Law No. 03-10 of 19 July 2003 on Environmental Protection within the Framework of Sustainable Development, Official Journal No. 52, dated 18 August 2004.

⁶Executive Decree No. 03-478 of 09 December 2003 determining the procedures for managing healthcare waste, Official Journal No. 78, p. 5.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

- Nursing homes for the elderly.

2- Secondary sources of waste:

These include the following elements¹:

- Small healthcare institutions such as dental clinics, acupuncture and manual therapy centers, as well as specialized healthcare facilities and low-waste-generating establishments such as convalescent and nursing institutions, psychiatric hospitals, and disability care institutions;

- Non-healthcare activities involving intravenous or subcutaneous procedures, such as cosmetic establishments performing ear piercing and tattooing, illicit drug users, as well as ambulance services and home healthcare services.

II. MECHANISMS FOR THE TREATMENT OF MEDICAL WASTE

Hospitals and other healthcare institutions are subject to a “duty of care towards the environment and public health,” and bear specific responsibilities with regard to the management of the waste they generate².

These responsibilities are based on methods aimed at altering the characteristics and properties of hazardous materials, thereby reducing their level of danger so as to enable their safe transport, collection, storage, and disposal without causing harm to individuals or the environment.

First: Methods of Medical Waste Management

1- Waste segregation (sorting):

It refers to the management of waste and the identification of quantities that require special treatment. It also reduces the costs associated with waste handling and contributes to the protection of public health. Waste segregation is carried out within healthcare institutions, where waste is placed in designated containers subject to a specific color-coding system³.

This process contributes to reducing the costs of waste handling, treatment, and disposal. In this regard, Articles 13 and 14 of Executive Decree No. 03-478 prohibit the mixing of healthcare activity waste and require its

¹World Health Organization Guide, Safe Management of Healthcare Waste, Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health Activities, Amman, Jordan, 2006, p. 10.

²Ibid., p. 10.

³Mohammed bin Ali Al-Zahrani & Faïda Abu Al-Jadaye, Sustainable Management of Medical Waste in the Arab World, paper presented at the Third Arab Conference on Environmental Management, Modern Trends in the Management of Environmentally Polluting Waste, Egypt, 21–22, p. 212.

segregation at the point of generation. Article 12 of the same decree also provides for the mandatory segregation of toxic waste, its packaging, and the labeling of containers to indicate its nature.¹

2- Color-coding system:

This system aims to identify the level and type of hazard associated with each category of medical waste that must be handled or treated.

3- Collection:

Sharp waste, whether contaminated or not, is collected in containers, usually made of metal or high-density plastic, equipped with tightly sealed lids to contain solid materials and prevent any liquid leakage.

Highly infectious waste is treated on-site through autoclaving or disinfection using chemical solutions. Cytotoxic waste is collected in strong, leak-proof containers, while pressurized containers are disposed of with non-hazardous healthcare waste, provided that such waste is not intended for incineration.²

4- Identification label:

It includes the essential information relating to medical waste, namely the type of waste and the generating department, as well as the biological hazard symbol placed on bags or containers used for the collection and storage of hazardous healthcare waste, together with the indication: "Hazardous Healthcare Waste." Waste contaminated with radioactive materials bears the international symbol, and the same applies to cytotoxic and genotoxic waste.

5- Storage:

In some cases, medical waste cannot be transported to central storage facilities due to distance or the large quantity of waste. Therefore, healthcare institutions designate specific rooms as temporary waste collection points.

These storage areas must display the biohazard symbol and be equipped with adequate lighting, ventilation, and hygiene conditions, including cleaning and disinfection materials and large waste containers inside the room. They must also allow easy entry and exit of waste transport trolleys. Medical waste must not be stored for prolonged periods and should be transferred to central storage areas in due time.³

¹Executive Decree No. 03-478, *supra*.

²*Ibid.*, p. 212.

³Mohammed bin Ali Al-Zahrani & Faïda Abu Al-Jadayel, p. 214.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

6- Central storage area:

This area must be divided into separate points for hazardous solid waste and non-hazardous medical waste. It should be located in enclosed buildings bearing the sign: “Access restricted to authorized personnel only.” Central storage facilities must be located away from fresh food storage and food preparation areas.

They should not contain cleaning and disinfection materials for daily use, except in emergency situations involving spills or leakage. The building must have an impermeable and heat-resistant floor, with adequate lighting, ventilation, and air-conditioning depending on the storage duration. It must also be equipped with multiple entry points to facilitate staff movement.

7- Transportation of medical waste:

This is a crucial stage as it involves the transport of all types of medical waste from healthcare institutions or facilities. Appropriate vehicles must therefore be provided for this purpose, and the carrier must hold a signed document confirming the receipt of waste.

Preference is given to vehicles equipped with self-loading systems for containers. Flatbed or open-sided trucks, as well as waste compactor vehicles, are not permitted for transporting hazardous medical waste in order to prevent any leakage into the surrounding environment.¹

Second: Methods of Medical Waste Treatment

These refer to the methods aimed at altering the characteristics and properties of medical waste in order to render it non-hazardous or less hazardous, thereby enabling its safe transport, collection, storage, or disposal without causing harm to individuals or the environment.

1- Thermal treatment of medical waste:

This involves the final disposal of ash and residues in safe pits or sanitary landfills located outside healthcare institutions, through the following methods²:

a- Incineration:

It is the process of burning waste in environmentally compliant incinerators, whereby waste is converted into ash using high temperatures

¹Ibid., same page.

²Ali Al-Anazi Saad, Health Administration, Dar Al-Yazouri Scientific Publishing and Distribution, Amman, 2008, p. 306.

under appropriate conditions. This method is the most widely used due to its ability to completely eliminate waste and significantly reduce its volume and weight.

b- Dry heat sterilization:

This method uses a hot-air oven at high temperatures for a prolonged period. It is applicable only for large quantities of hazardous medical waste.

2- Sterilization treatment of hazardous medical waste:

This is carried out through the following techniques¹:

a- Moist heat sterilization:

Also known as steam sterilization, this method involves exposing waste to saturated steam under high pressure in closed systems known as “autoclaves.” In some cases, waste must be shredded into smaller particles. However, this method is not suitable for pharmaceutical waste, chemical waste, human pathological waste, or any waste that is impermeable to steam.

b- Microwave sterilization:

Water contained within the waste is rapidly heated using microwave radiation, leading to the destruction of infectious agents. This method is considered safe when properly applied; however, it is costly in operation and is mainly used for liquid medical waste and infectious waste containing fluids.

c- Chemical sterilization:

This method involves exposing waste to chemical agents with antimicrobial properties. Its cost depends on the chemicals used. It requires highly skilled technicians and strict safety standards to prevent risks to individuals and the environment.

3- Land-based treatment of hazardous medical waste:

Land-based treatment of hazardous medical waste containing organic substances leads to the aerobic decomposition of microorganisms and microorganisms, due to the presence of organic matter and liquids within the waste. This decomposition process occurs over months or years under the influence of temperature, as well as the availability of air and water. Land-based treatment of medical waste involves several mechanisms²:

¹Saadi Nabiha, Urban Waste Management in Algeria: Reality and Required Effectiveness, Master's thesis in Economics, University of Boumerdès, Algeria, 2012, p. 71.

²Ali Al-Anazi Saad, op. cit., p. 309.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

a- Landfilling:

Landfill sites require specific engineering standards based on a geological assessment of the location to ensure that the environment is not harmed through the leakage of liquids resulting from waste decomposition into groundwater. This method relies on disposing of hazardous waste in designated sites to accommodate large quantities and reduce waste volume, with daily covering using an impermeable clay layer to prevent seepage.

b- Stabilization or solidification:

This method is used for expired pharmaceuticals and involves mixing them with cement, lime, and water in specific proportions in order to neutralize their active properties and limit their dispersion in the environment. The treated waste is then transferred to an appropriate landfill site.

However, this method is not effective for infectious waste or waste containing pathogenic microorganisms. In addition, several techniques have not proven effective for treating large quantities of hazardous medical waste, such as gas sterilization, hot air sterilization, and ultraviolet (UV) radiation treatment.

III. THE ENVIRONMENTAL IMPACTS OF MEDICAL WASTE

It is observed that most countries have been affected by various environmental and health problems resulting from medical waste, due to the unsafe disposal of such waste or the neglect of preventive measures.

The extent of its harm is difficult to enumerate or limit due to variations in regulatory approaches across different legal systems. Therefore, it is necessary to highlight the seriousness of this type of waste, particularly its health and environmental impacts, as follows:

First: Environmental damages caused by medical waste

Hospital and healthcare institution waste is considered one of the most serious threats to individuals and society in general, and to healthcare workers in particular, due to the diseases and rapidly spreading epidemics it contains, which are physically and materially destructive, in addition to the environmental damage it causes. Accordingly, medical waste does not only affect human health but also the environment. The main environmental impacts can be summarized as follows:

1- Environmental damages, including:

1-1 Water pollution:

The hydrosphere covers more than 70% of the Earth's surface, with an estimated volume of approximately 296 million cubic miles of water. This highlights the importance of water as a fundamental source of life on Earth, which must be protected and preserved to maintain ecological balance, which is essential for the continuity of life.

From a natural perspective, water pollution refers to the disruption and degradation of water quality and its ecological system, rendering it unfit for its essential uses and unable to absorb particles, microorganisms, and various wastes within its ecological balance. This leads to a disturbance in the system until it reaches a critical ecological threshold, beyond which harmful environmental effects begin to appear.

The indiscriminate disposal of waste through traditional low-standard methods, such as dumping into deep wells—as in the case of the Clark Fork site in Montana, United States, one of the largest waste dumping sites in the world—leads to environmental, soil, and groundwater contamination due to leakage of hazardous waste into landfill areas. Similarly, thousands of residents of Minamata, Japan, suffered from neurological disorders after consuming fish contaminated as a result of hazardous waste being discharged into the sea¹.

It is worth noting that African countries are among the most affected by hazardous waste pollution in general, and medical waste in particular, as their lands and coasts have often been used as dumping sites for medical waste originating from developed countries.

1-2 Soil pollution:

Soil pollution refers to the contamination of the lithosphere and the upper layer of the Earth's crust, which constitutes the first and fundamental component of the ecological system and represents the basis of life and its continuity. Undoubtedly, the significant population growth witnessed in recent years has placed substantial pressure on the environmental components of this part of the ecosystem, leading to the depletion of many environmental resources as a result of human inability to preserve and protect them from degradation.

¹Kamel Mohammed Al-Maghribi, Management, Environment and Public Policy, International Scientific House, Dar Al-Thaqafa Publishing and Distribution, 1st ed., Amman-Jordan, 2001, p. 238.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

Improper use of agricultural land leads to a decline in its productivity, transforming it from a productive element into a non-productive one with biological capacity that may reach zero. Furthermore, misuse of technology has contributed to the emergence of soil pollution, particularly through the increased use of nitrogen fertilizers to compensate soil with chemicals, which in turn degrades its biological capacity. In addition, the expansion of industrial and mining activities has led to an increase in pollutants and solid waste, whether chemical or radioactive. Some governments dispose of such waste by dumping it on land or burying it underground; in both cases, the negative impact is evident and affects humans, animals, and plants in the long term.¹

1-3 Visual pollution and environmental degradation:

Hospital waste causes harm to society, resulting in discomfort and heightened sensitivity among individuals due to exposure to medical waste containing human remains and contaminated blood. One of the consequences of medical waste is the distortion of the urban landscape and surrounding environment through the spread of foul odors and the proliferation of flies and disease vectors such as cockroaches, rodents, and stray animals, all of which contribute to the spread of infectious diseases.

According to a World Health Organization report on the problems and risks of waste in developing countries, most diseases recorded in hospitals in such countries are caused by the transmission of microorganisms through insects, parasites, rats, cockroaches, and similar vectors. Humans are also visually affected by the sight of accumulated waste piles, which generates feelings of discomfort and distress.²

1-4 Air pollution:

Air pollution refers to the contamination of air with toxic gases, smoke, dust, and harmful or poisonous vapors emitted from various sources such as incinerators and landfills. When non-hazardous healthcare waste—which constitutes the largest proportion of medical waste—is incinerated, it produces significant amounts of carbon monoxide and carbon dioxide.

Carbon monoxide is characterized by its ability to bind with hemoglobin in the blood at a rate approximately 300 times higher than oxygen, thereby

¹Ahmed Hajjaj & Aisha Issaoui, *The Impact of Hospital Waste on the Environment and Society*, Al-Mahkama Journal for Social Studies, No. 4, 2020, p. 74.

²Mohammed Al-Sayyid Arnaout, *Methods of Benefiting from Garbage and Solid and Liquid Waste*, Arab House Library Press, Cairo–Egypt, p. 28.

reducing the amount of oxygen reaching the brain, which leads to serious risks to public health. Air pollution also includes fine particles, hydrocarbons, sulfur oxides, and other harmful airborne pollutants.¹

2- Economic impacts of medical waste:

The damages caused by medical waste are not limited to public health and environmental harm but also extend to the economic sphere. One of the main reasons for the unsafe disposal of medical waste is the high financial cost of its lawful treatment and disposal. Environmental decontamination projects and the treatment of diseases caused by pollution impose significant financial burdens on states.

Moreover, pollution destroys resources that, in some countries, represent the primary source of livelihood, thereby contributing to the spread of poverty and unemployment. This includes the destruction of agricultural wealth through soil contamination, poisoning of crops, and contamination of aquatic organisms, which negatively affects marine resources and the fishing industry. Furthermore, toxic substances released indiscriminately into the environment may persist for decades. Due to the severe economic consequences of environmental crimes, some scholars classify environmental pollution as an economic crime.

Conclusion:

Environmental protection has long been regarded as one of the most significant concerns for humankind since its existence on Earth, as it constitutes the fundamental environment within which human life is sustained and ensured. In conclusion of this study, which has examined the legal framework governing the management of medical waste in Algerian legislation and its environmental impacts, it can be observed that medical waste is increasing significantly, due both to population growth on the one hand and to scientific and technological advancements within the healthcare system on the other.

From this perspective, the importance of establishing a specific regulatory framework for the management of medical waste becomes evident, in order to ensure its safe disposal, particularly in light of the scientific evidence confirming that this type of waste constitutes a source and cause of infection when improperly handled. It also gives rise to severe environmental, health, economic, social, and even psychological impacts.

¹Hassan Ahmed Shehata, *Environmental Pollution: Wrong Behaviors and Ways to Confront Them*, Arab House Library Press, Cairo–Egypt, 2003, pp. 73–74.

The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

This necessitates the development of modern mechanisms and appropriate methods aimed at ensuring the safe and sound management of waste disposal at the lowest possible cost, while minimizing the resulting harm. Accordingly, the national legislator, as well as most comparative legal systems, has devoted particular attention to medical waste through the enactment of legal provisions governing its management and transportation, as well as the declaration of hazardous special waste, thereby imposing numerous obligations on the generators of medical waste within this framework.

In light of the findings reached, a number of recommendations may be proposed as follows:

- Establish training programs in the field of medical waste segregation and management, and reinforce healthcare institutions with qualified human resources to ensure the safe management of this type of waste, particularly given that such tasks are often assigned to sanitation workers, many of whom lack basic literacy skills, thereby increasing their exposure to the risks associated with such waste;
- Allocate dedicated budgets for the disposal of hazardous waste within each healthcare institution, alongside the implementation of regular maintenance of incineration facilities within medical establishments;
- Organize conferences and study days, and strengthen international cooperation in order to support research and studies related to the management of medical waste in all its forms;
- Establish a designated position responsible for medical waste management, operating under the supervision of the head of the healthcare institution, tasked with defining responsibilities, distributing duties related to the management, treatment, and disposal of medical waste, and preparing written reports and records on the progress of such operations for submission to the competent authorities;
- Promote a public health culture aimed at changing behaviors and practices, and conduct awareness-raising campaigns on the importance of developing medical waste management programs and their positive economic, health, and environmental impacts.

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The Regulation of Medical Waste Management in Algerian Legislation and Its Environmental Impacts

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