

# Overview of Clinical Waste Management in Malaysia

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**ABSTRACT:** Clinical waste management system in Malaysia was established in 1980 after the emergence of HIV. Ministry of Health of Malaysia and the Department of Environment Malaysia have revised the current policies and guidelines to control infectious disease and handling clinical waste. The clinical waste management services are managed by private consortiums under the supervision of the government according to the Scheduled Waste Regulation 2005. The disposal method through incineration process turns the clinical waste into ash and disposed of at the approved landfill site. Malaysia also practicing recycling and recovery of non-infectious clinical waste to reduce the cost and minimize waste generation. However, clinical waste management became an issue due to the outbreak of COVID-19 in December 2019 posing a serious impact on all parts of society. The waste generated sharply increased with the quantity demanded disposal gloves, face masks, etc in the hospital. Incinerate clinical waste destroys the pathogen effectively, reduces the chance of transmission disease and yet potentially releasing secondary pollutants of gas emission and required landfill site for final disposal. Landfilling is not a sustainable and long-term solution because of the toxic leachate and greenhouse gas emission as well as the limited land in the future.

**KEYWORDS:** Environmental pollution; waste management; clinical waste; incineration; landfilling

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## 1. Introduction

The generation rate of clinical waste depends on the different economic levels, country development, size and type of medical institution, and amount of patient care [1]. Clinical waste refers to the discarded materials from the healthcare facilities such as hospitals, dental, and veterinary, and other related facilities such as laboratory and autopsy [2]. Clinical wastes contain sharps, body excreta, and other infectious substances that may be infectious, pathogenic, and radioactive, therefore posing a certain degree of hazard to the environment and exposed public [3]–[5]. Therefore, they should be managed and handled properly. However, waste management is not an easy task because it requires a comprehensive consideration of many aspects, including economical, technical, social, and environmental [6].

In Malaysia, clinical waste generation from healthcare facilities has rapidly increased over the past few decades, and the outbreak of COVID-19 recently doubled the clinical waste

generation. In comparison to the volume of other waste streams, clinical waste only represents a smaller portion of the total waste generated [7], but this small portion of the solid waste stream is potentially infectious and hazardous which can pose serious impacts to human health and the environment if not handled and disposed of properly. Poor clinical waste management leads to disease transmission through infectious agents, environmental compartment contamination including soil and water contaminated by hazardous chemicals, and potential causes of human injury via improperly discarded sharp instruments [5], [8], [9]. As for public health and environmental concern, a guideline for handling and managing clinical wastes has been prepared by a regulatory agency or government of Malaysia.

A proper clinical waste management system is only established in Malaysia since 1980, which is after the emergence of HIV or AIDS [6], [10]. The first initiatives took by the Ministry of Health of Malaysia (MOH) in collaboration with the Department of Environment Malaysia (DOE) to revise the policies and guidelines to control infectious disease and the handling of clinical waste [11]. All the aspect of clinical waste management is responsible by the DOE and Federal government until the implementation of the privatization program for clinical waste management due to the limited resources from the government. Three private consortia namely Faber Medi-Serve Sdn Bhd, Radicare (M) Sdn Bhd, and Pantai Medivest Sdn Bhd, are nominated to provide clinical waste management services include storage, collection, transportation, treatment, and final disposal from the government hospitals [6], [12]. Clinical waste management processes should follow the policy and legislation detailed in the Environmental Quality Act (Schedule Waste) 2005, and the standard operating procedure prepared by MOH [13].

Clinical waste generation in Malaysia was reported up to 33,000 tonnes per year. The rate of clinical waste generation is different for each healthcare facility, depending on the number of patients' care, size, and type of medical institution [1]. On average, 1.9 kg/bed/day of healthcare waste produced in Malaysia, which is higher than that reported in Thailand, India, and China, but less than in South America and Western Europe [1], [14].

## **2. Guidelines on Handling and Management of Clinical Wastes**

In Malaysia, clinical waste is controlled under the Environmental Quality (Scheduled Waste) Regulation 2005 by following the standard operating procedure [15]. This regulation outlined the practices and requirements for the clinical waste generator to comply with and rationalizing consistent clinical waste management methods within the country. The definition of waste generated in healthcare facilities, source identification and classification by groups are specified. This is to ensure a better and common understanding of clinical waste management in Malaysia. Under the regulation, clinical waste is defined as the wastes produced from healthcare or other related facilities that contained human or animal tissue, body excreta, blood, drug, pharmaceutical substances, soiled swabs, syringes, and sharps which hazardous to human [15], [16].

## **3. Clinical waste management in Malaysia**

Before 1990, clinical waste management was not established in Malaysia and the approach taken was similar to the general waste within the hospital [11]. As a consequence, transmission diseases occurred, drastically action taken by MOH and DOE to develop a guideline and

standard procedure for clinical waste management. However, regulation and management practices were not fully implemented because of the lack of resources and infrastructure. To resolve the issues, government privatize the clinical waste management services by awarding the contract to three concession companies. Typical management approaches are similar by following standard operating procedure and guidelines specified in Schedule Waste Regulation 2005 [15]. Clinical waste segregation, labelling and marking, collection and storage, internal transportation to central storage, transportation to approved facility, documentation, treatment, and final disposal form are basic requirements in environmental management practices to minimize the potential hazard on public health and environmental contamination. These steps will be further elaborate in the following section.

### *3.1. Source separation, labelling, storage, internal transportation, collection*

The first step in clinical waste management is the segregation of clinical waste, in which the nursing and clinical staff sort the clinical waste at the source through colour-coding as stipulated in the guideline. Colour-coding was adopted to segregate the different types of clinical wastes [14], [17]. General wastes deposited in black bags, while clinical wastes in yellow bags and will be directly incinerated, light blue bags contained the wastes for autoclaving [18]. Sorting clinical waste become primary environmental management practice, through that several treatment techniques were used to treat the clinical waste at varying hazard level. Clinical wastes with coded blue are replaced into a yellow bag or container after the autoclaving process for incineration or ultimate disposal. Sharps are deposited in sharp bins only. Upon deposited the clinical wastes into the bags, the containers mark with a biohazard symbol and label appropriately with the start date of the scheduled wastes generated and the information of the waste generators. The bags or containers that  $\frac{3}{4}$  full of wastes will be sent to the central storage, isolated from the general waste collection point and locked until collection day for treatment. It is necessary to limit the exposure of infectious or toxic waste, especially to stray dogs and cats, thereby minimizing the transmission of bacteria and diseases. Specific wheeled containers or trolleys are used by the trained porter to transport the isolated clinical wastes to the central clinical waste storage. The trolley and container are to be cleaned and disinfected thoroughly after the transportation of clinical wastes to central storage [19]. The central storage is refrigerated to store the wastes no longer than 48 hours before collected by porters and transported to the incineration plant. Hospital personnel is compulsory to provide and verify documentation and record of the clinical wastes which being treated or disposed of at the landfill sites [15].

### *3.2. Clinical Waste Treatment*

Several treatment methods are available to treat clinical waste globally, such as incineration, autoclave, microwaving, chemical disinfection, etc. The clinical waste treatment methods adopted in Malaysia are incineration and landfilling. Autoclaving and recovery and recycling are not actively adopted in Malaysia [1].

#### *3.2.1. Incineration*

Incineration is a high thermal heat oxidation process that burns wastes into residual ash and smoke. Thermal decomposition is necessary before disposing of clinical waste at the landfill

site to kill infectious or hazardous pathogens [20]. In Malaysia, incineration is a popular treatment method for handling infectious and hazardous waste. Its benefits include eliminating pathogen and anatomic wastes, reduce bulk volume of waste, and energy recovery [21]. However, the potential of producing secondary toxic gases remains the primary disadvantage of incineration, contributes to air pollution and poses risks to human health [22], [23]. Clinical wastes contained a large amount of chlorine composition source from plastic or PVC discarded materials, and disinfectant compounds. The chlorine-containing wastes possibly released toxic and carcinogenic gaseous (dioxin and furan) from incomplete combustion of PVC-based materials [21], [24]. The emission also associated with heavy metals for example arsenic, lead, iron, and nickel, which formed in small particulates, vapours, and ashes [25]. Incineration also requires high capital, operating, and maintenance cost and disposal of ash at the landfill site [26], [27]. Up to date, incineration becomes a debating topic among the public, environmental activists, business interest partners, and regulatory makers. Poor design of incineration system and operational problems arise from the incineration process had become the major concern of the public banned the construction of incineration plant. Yet, incineration is the currently available and safest method to manage infectious clinical waste in Malaysia.

### 3.2.2. Autoclave

Autoclaving or known as steam sterilization also used for treating clinical waste in Malaysia but not actively implemented. An autoclave is a metal vessel with a sealable door, pipes and hatches arrange through which the steam is pass through the vessel and operate in high pressure and temperature condition [6]. As a standard operation, clinical waste to be autoclaved is deposited in blue colour bags. The waste is shredded to a smaller size of less than 2 cm before sterilizing process [6]. At a smaller size, the waste is easier to handle and sterilized effectively. This method is known to efficiently disinfect most microorganism's types attribute to the sufficient time and temperature given and close contact between steam and waste that could kill the microbial spores [27]. In terms of limitation, the autoclave is applied especially for highly infectious clinical waste such as lab cultures and sharps. Chemical and hazardous clinical waste such as chemotherapy waste, volatile or semi-volatile organic wastes, radioactive wastes, and mercury-containing waste cannot be treated by autoclave. The autoclave operates for 30-60 minutes at 121-163°C above 1 atm pressure to destroy spores [5], [28], [29]. Then, the waste will be sent to the landfill for final disposal or incinerated as the autoclaved products not accepted by the public to dispose directly at the landfill site [27]. Double treatment is not cost-efficient, therefore most of the clinical waste in Malaysia is incinerated [30]. Medical equipment after autoclaved can be reused because the process effectively inactivates the pathogenic microbes. However, pathogenic bacteria can re-growth a few days after being autoclaved. Studies on optimizing autoclave indicated the process parameter such as temperature and exposure duration influenced the re-growth factor [31].

### 3.2.3. Landfilling

Landfilling is the next stage of clinical waste treatment other than incineration and autoclaving. The fly ash is the by-product of the incineration process that needs to be disposed of in the landfill [32]. Infectious clinical waste after incineration killed the pathogens and microorganisms, therefore posing the least environmental impacts. Fly ash also can be used as

soil coverage [33]. However, the landfill method can cause environmental pollution and posing health risks to human health if not operating and maintaining properly and carefully. The risks arise from the leachate and gas generated from the landfill have chances to contaminate the soil and groundwater, causes unpleasant odour, and increase atmosphere temperature [34], [35]. Leachate and gas monitoring systems such as leachate containment systems, drainage systems, and flow gas meters are equipped in landfill sites. Due to the risk associated with landfilling and limited space available in the future, alternative technology for clinical waste treatment is needed.

#### *3.2.4. Recycling-reuse*

Recycling and recovery are other environmental practices for managing clinical waste in Malaysia. Experts will look for the discarded clinical materials that can be recycled and recovered after sterilized. The recyclable materials in the clinical waste stream are high because of the high plastic content of the medical waste stream, make them reusable and recyclable [36], [37]. The recycling-reuse program not only reduces the clinical waste generation but also save the cost of purchasing new equipment and cost of disposal. Reducing the amount of clinical waste will reduce the volume of waste for incineration, thereby reducing the emission of furan and dioxin that caused detrimental health risks to the public. A cost-effective and reliable treatment method to disinfect and sterilize clinical waste should be developed for the recycling-reuse program of clinical waste to be well-implemented. Besides, a clear plan should be established to identify the waste that has to manage as infectious to reduce the amount of clinical waste [37]. In Penang, a well-established recycling system that collects and handles the clinical waste properly following the local regulation is developed in Hospital Lam Wah Eye [38]. The hospital generates revenue from the recycling program, showing a high commitment to healthcare waste management, and proved that the recycling system can be a self-sustaining approach.

#### *3.2.5. Microwaving*

Alternative treatment methods that have been proposed in research studies but not implemented in Malaysia is microwave. Microwaving technology is a steam-based process that uses high-intensity radiation to heat the moisture of the waste sample or add extra steam to sterilize infectious and pathogenic components [6], [39], [40]. Banana et al. [41] conducted a study to investigate the potential use of dry sterilization by microwave on the clinical waste sample obtained from one of the general hospitals in Penang. The study suggests that 5 minutes of exposure to microwave irradiation sufficiently sterilize the clinical waste and the process is enhanced with increasing temperature and time. At high applied wattage and long exposure time, infectious microbes are reduced below the detection limit. However, gram-negative bacteria are resistant to microwave irradiation and the re-growth ability of microbes depends on the moisture content of clinical waste [41]. Another research studied by Mahdi et al. [29] revealed microwave radiation in clinical waste treatment is better than other heat disinfection because of the less time consumption, cost-effectiveness, and causing no harm to the environment. Microwaving clinical waste is more economically competitive than incineration [42]. The interesting point from their study is that microwave radiation itself regardless of the thermal effect of radiation contributes to the microbe disinfection, making the treatment

method cost-effective. Disadvantages of microwave include the high cost, generate offensive odour, and limit to a certain type of clinical wastes [6], [43]. Further research study on the optimization and potential use of microwave to disinfect clinical waste are required.

#### **4. Challenges of clinical wastes management in Malaysia**

Malaysia is believed to have a better healthcare standard and services, and a cheaper cost of treatment in comparison to some other countries in healthcare services, which lead to the generation of a huge amount of clinical waste [44]. There are many foreign patients to come over to be treated in Malaysia, therefore an increase in clinical waste generation is expected [6]. Based on the inpatient record from one of the hospitals in Penang, Indonesia outpatients alone accounted for 10-20 % monthly revenue in the year 2003, where the medical services most in demand by foreign patients are general medical screening, cardiology, general surgery, and orthopaedic services [45]. Recently, the outbreak of COVID-19 in December 2019 posing a serious impact on all parts of society, and clinical waste management is no exception. Malaysia has reported a 27% increase in clinical waste generation due to the pandemic, and the most increase in hospital waste are disposal gloves, sharps, needles, face masks, and personal protective equipment [13], [46]. Those clinical wastes are managed through the same regulation as other clinical wastes. Despite clinical waste from healthcare facilities, clinical waste from households also increasing when medical and healthcare services at home become a necessity for the population [47]. In addition, face masks experience a substantial increase in use by the public during the pandemic, which contributes to the increase in household clinical wastes. The most serious issue is that the users do not discard the face masks properly as evident by the phenomenon where the face masks can be seen everywhere along the roadside and street [19], [48]. The clinical waste generates from the household medical care also mixed with general household waste. This poses health risks to the municipal workers who are assigned to collect waste from the household, shop lots, and street cleaners. Because of these issues, the future challenge that can be expected would be the sharp increase of clinical wastes that will eventually override the clinical waste treatment capacity which is incineration due to the small scale incineration plant and the insufficient financial and resources. Besides, public awareness and education on clinical waste management are low as can be observed from the improper handling of household clinical waste which increases the risk of disease transmission through direct contact or indirectly through the environment.

Challenges also fall on the incineration technology as the common treatment method for clinical waste and the final disposal into the landfill [49]. Even though incineration can effectively kill pathogens and infectious microorganisms, the high operating cost and the associated environmental impacts and health risks to humans and animals still become the major concern [50]. It is generally known that incineration of a high fraction of plastic-based materials releasing a substantial amount of dioxin and furan. Landfilling the fly ash from the incineration process produce secondary pollutants if it is not managed properly. Incineration and landfilling are not sustainable method for managing the clinical wastes because of the scarcity of land and the associated high cost to offset the resulting air and water pollution. Hence, the challenge of clinical waste management in Malaysia includes the searching for sustainable and long-term waste treatment method.

As a recommendation, recycle and reuse of clinical wastes would be the best method to minimize the ever-increasing clinical waste that is to be treated by incineration. Recyclable

clinical waste includes the discarded PVC products, such as syringes, infusion tubing, and bags, or any other material that do not carry infectious microbes [51]. Disinfection of the used medical wastes can be carried out before reuse again. This practice is not currently developed in Malaysia because the viewpoint of single-use medical products minimizes hazardous exposure and infectious pathogens, which is more reliable. In consideration of these issues, more advanced treatment technologies to disinfect the medical instrument will be required and proper source aggregation to reduce the transmission of the infectious pathogen to increase the recycling of non-infected medical equipment. Microwaving and autoclaves can be considered to sterilize the infectious clinical waste to increase the reuse potential of discarded clinical equipment. Besides, alternative treatment methods that are more environment-friendly in managing clinical waste should be encouraged to replace incineration [49]. Several treatment technologies undertaken by other countries such as microwaving, chemical disinfection, gasification, and pyrolysis can be considered [52]. However, it should be studied well through research and experiment to evaluate the suitability of the waste treatment system before implemented in Malaysia. It should consider the social, economic, and environmental aspects for the treatment technologies to be officially implemented.

Government or regulation makers are recommended to enhance the regulating of policy programs and revised the cost of managing clinical wastes in Malaysia. Even though the guideline and regulations in handling a variety of clinical wastes are available, but the knowledge of managing clinical waste is still low among the public as well as the hospital staff. The staff of the healthcare facilities should be trained consistently to improve the clinical waste segregation at the source [53]. Importantly, the concession company should send the porters for consistent training so that they follow the standard procedure in collecting, handling, and transporting the clinical waste. The process of clinical waste management before treatment also needs to be monitored strictly to ensure clinical waste management practices comply with the standard operation and procedure. Cooperation and involvement of the public in the sorting of waste and properly managing the clinical waste is important to ensure successful clinical waste management and reduce the health risks. Therefore, public education on clinical waste management can be implemented through posters or advertisements, as well as through the educational institution.

## 5. Conclusion

The generation rate of clinical waste in Malaysia has been rising and the outbreak of COVID-19 further increases the rate. The management of clinical waste in Malaysia is of major concern because of the potential risks to the environment and human health. The movement to regulate clinical waste management has been developed by the Malaysian government through Scheduled Waste Regulation 2005 and the proposed guidelines handbook in handling a variety of clinical waste to reduce the exposure of infectious, hazardous, and radioactive wastes from the related healthcare facilities. Clinical waste management in Malaysia is performed through a privatization program in which the concession company is fully responsible for the process of clinical waste management including the provision of clinical waste equipment such as waste bags and containers, except the waste segregation which is performed at source by hospital staffs. The practices of clinical waste management in most of the government hospital is similar where the hospital staffs required to segregate the clinical waste into the right colour-coded waste bags with appropriate labelling. The authorized concession companies will send their

porters to the hospitals to collect the waste bag and containers at the central storage or place-to-place at each department and wards. Currently, the collected clinical wastes will be sent to the incineration plant and the by-product from the incinerator will be disposed of at the landfill site. Incineration decreases the waste volume and reduces the space to landfill the waste. However, the emission of toxic smoke from the incineration plant has still become the major concern of the public. Therefore, future research is encouraged to search for a more sustainable and environmental-friendly clinical waste treatment to replace incineration. Recycling and reduction of clinical waste are the most promising environmental practice of clinical waste management.

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## Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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