

Waste Management during the COVID-19 Pandemic

From Response to Recovery



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United Nations Environment Programme,
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Foreword by Mr. Keith Alverson

The COVID-19 pandemic is posing enormous challenges at every level of society and across economic sectors. Despite occasional rhetoric to the contrary, there is never a simple trade-off between health care concerns and economic ones. Rather, there are many actions to take across a wide health care and economic spectrum that deliver positive outcomes with regard to both COVID-19 as well as social and economic resilience. For solid waste management, municipalities are faced with the challenge of continuing essential services of waste collection and management while at the same time accounting for growing streams of potentially infectious waste, and protecting the lives of formal and informal workers. One of the primary messages from UNEP is to use existing waste management systems to their fullest, whenever possible. There's an old saying in emergency management: "disaster is the wrong time to exchange business cards", similarly in the midst of a pandemic is usually the wrong time to try to install new health care waste management systems and practices from scratch.

This said, the COVID-19 pandemic disaster, unlike earthquakes or tropical storms, will not be over in a matter of hours or days. It will be with us for another year at least, and possibly for several more years. Indeed, we face the inevitability of localized additional natural disasters occurring during the pandemic, multiplying waste management challenges. Thus, in addition to addressing immediate concerns, there is also an opportunity, over the longer term, to improve waste management systems and build a better future in light of lessons being learned today. We hope that this publication, with its combined 'desk review' of international guidelines alongside country level 'facts on the ground' survey responses, will provide some guidance and practices for municipalities, particularly in developing countries, as they deal with urgent concerns, and building more resilient cities for tomorrow.



Mr. Keith Alverson
Director, International Environmental
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Mr. Keith Alverson

Director
UNEP-IETC

Foreword by Mr. Kazunobu Onogawa

COVID-19 has had a serious impact on all parts of our society, and waste management is no exception. Waste management in developing countries is usually not operated in accordance with international standards, and so there have been additional difficulties with an increased amount of potentially infected waste which requires additional, careful handling and treatment processes.

International organizations and academic associations have already issued guidelines for infectious waste management. However, many of those guidelines target both developed and developing countries, and only a few guidelines are prepared specifically in response to the current condition of COVID-19 waste management in developing countries. The state of waste management in those countries differs from that in developed countries, and it is difficult to apply developed countries guidelines as they are. Particularly, developing countries lack capacity in terms of financial, technical, social, and institutional aspects.

In addition, many of the available guidelines have been developed when society is under normal conditions, rather than in the midst of a pandemic. Guidelines prepared under such conditions usually focus on the technical parts of waste management without paying sufficient attention to the potentially confused state of society hit by a pandemic. The already limited capacity of waste management in developing countries is further affected by COVID-19 waste which requires additional careful consideration and operation.

Developing countries have to react to COVID-19 under such conditions and need to find an answer for themselves. It is not an easy task to find a universal landing point between desirable goals and affordable ones, and that is why setting individual goals is left to the decisions of respective governments and municipalities.

This report is unique in that it highlights communications with governments and municipalities of developing countries as we collect real information on the ground. While international guidelines are usually targeting final goals, this report aims to compile information on the technologies and institutional arrangements currently employed in developing countries.



Mr. Kazunobu Onogawa
Director, IGES Centre
Collaborating with UNEP on
Environmental Technologies

Referring to the 17 guidelines suggested by international organizations and other authorities, we have communicated with 14 developing countries around the world with regards to 29 of their national regulations and compiled their responses and information in this report. Our objective is to share this real information with countries seeking such information for their decision-making process. Observations from leading experts based in developing countries, and who are familiar with the real situation of waste management in those countries are another important contribution to this report.

There is often a large gap between what is discussed and what is implemented in the area of waste management. The question is how to fill this gap, and that is what we intended to share in this report. What we need are practical ideas and examples on how to handle situations under the disastrous conditions caused by the current COVID-19 pandemic.

We hope this report will serve as valuable information for consideration and development of action plans in developing countries and economies in transition, so that they can better handle healthcare waste management generated by COVID-19.

Mr. Kazunobu Onogawa
Director, CCET
IGES

Abbreviations

ADB	Asian Development Bank
BAT	Best Available Technique
CBWTF	Common Bio-medical Waste Treatment Facility
CCET	IGES Centre Collaborating with UNEP on Environmental Technologies
CIMT	Centre for IMT-GT Subregional Cooperation
COVID-19	Coronavirus disease 2019
CDC	Centers for Disease Control and Prevention
IGES	Institute for Global Environmental Strategies
HCWM	Healthcare Waste Management
ISWA	The International Solid Waste Association
OSH	Occupational Safety and Health
MSWM	Municipal Solid Waste Management
PPE	Personal Protective Equipment
SACEP	South Asia Co-operative Environment Programme
WHO	World Health Organization
UNEP-IETC	United Nations Environment Programme - International Environmental Technology Centre
UN-HABITAT	United Nations Human Settlements Programme

Summary

This report provides practical information, suggestions, and guidelines on Healthcare Waste Management (HCWM) and Municipal Solid Waste Management (MSWM) given the restrictions and limitations imposed by the ongoing pandemic, including lack of human resources, technologies, equipment, and funds. This report builds on existing and ad-hoc information rapidly extracted from existing documents as well as responses to a national questionnaire survey. The report introduces various practices including best available options for immediate consideration as well as those for sustainable healthcare waste management in the future, with a focus on developing countries.

COVID-19 creates additional challenges in waste management in developing countries. Inadequate and inappropriate handling of healthcare waste may have serious public health consequences and a significant impact on the environment. Sound management of these wastes, in addition to municipal solid waste (MSW) and other growing waste streams such as electronic waste (E-waste), construction and demolition (C&D) waste and industrial waste, is thus a crucial part of environmental and health protection. The importance of proper management of healthcare waste has been receiving further attention with COVID-19 pandemic, newly discovered in late 2019. As shown in Table 1, developing countries that may already lack

proper healthcare and municipal solid waste management practices due to technical, operational, and/or financial constraints are particularly vulnerable during the pandemic, with its new risks and challenges.

Governments have introduced some initiatives, but they are inadequate. On a positive note, awareness about potential harm from healthcare waste has now become more prominent, not only within governments, medical practitioners, and medical waste handlers, but also within the civil society. Most governments have started to follow existing legislation and regulations put in place by their respective countries for the management of infectious waste from hospitals and households. Further, some governments continue to introduce new policies and guidance to follow in handling waste under the COVID-19 pandemic, considering the additional capacity and resources are required to maintain compliance for proper waste management. In addition, governments which do not have their own policies or guidance have taken actions to operationalize the international regulations and guidance issued by different agencies, including WHO, UNEP, UN-Habitat, the World Bank and other UN agencies, as well as other international organizations such as ADB and ISWA.

Table 1 - Risks and challenges associated with waste management in COVID-19 pandemic

Waste generated through household/ domestic waste management (MSW)



- » Increased amount of mixed waste, including infectious waste due to low levels of segregation at source
- » Increased amount of plastic waste (due to lockdowns, suspension of reusable items in stores, etc.)
- » Lack of inventorisation/estimates on amount of household hazardous waste being generated
- » Increased littering, illegal dumping and open burning
- » Suspension of recycling activities
- » Mixing of infectious waste such as gloves, masks, tissues, and gauze with other wastes (exposure to transmission)
- » Discontinued provision of formal/informal waste management services
- » Increased negative impacts, especially to informal sector (OSH, health risk, business opportunity loss, etc.)
- » Improper MSWM service provided during normal times (vulnerability in collection services and landfill operation as well as OSH)
- » Lack of awareness regarding waste management
- » Reuse of disposed PPE
- » Lack of daily supply of PPEs to waste collectors

Waste generated through healthcare facilities



- » Increased amount of infectious waste generation
- » service interruptions of healthcare waste management services
- » Improper healthcare waste management treatment in place
- » Suspension of recycling activities
- » Insufficient capacity for waste treatment and disposal



Good governance and policy-making responsibility play an important role throughout the emergency management cycle – from preparedness and readiness to response to eventual evidence-based recovery from COVID-19.

Proper management of healthcare waste needs to be based on the waste hierarchy/3R principles and consider integrated and/or holistic management, starting from source segregation, storage, collection/transport, treatment and final disposal. Although most governments have made some efforts to improve the situation, findings from a questionnaire survey (Table 2) show they are inadequate to manage even the healthcare waste that is generated in normal times.

With these limited technical options and capacities, the COVID-19 pandemic and the associated increase in volume of healthcare waste generation created additional burdens for both local and national governments. To respond to this emergency adequately, each government needs to develop a contingency plan based on the local conditions and requirements.

Table 2 - The summary of the questionnaire survey results

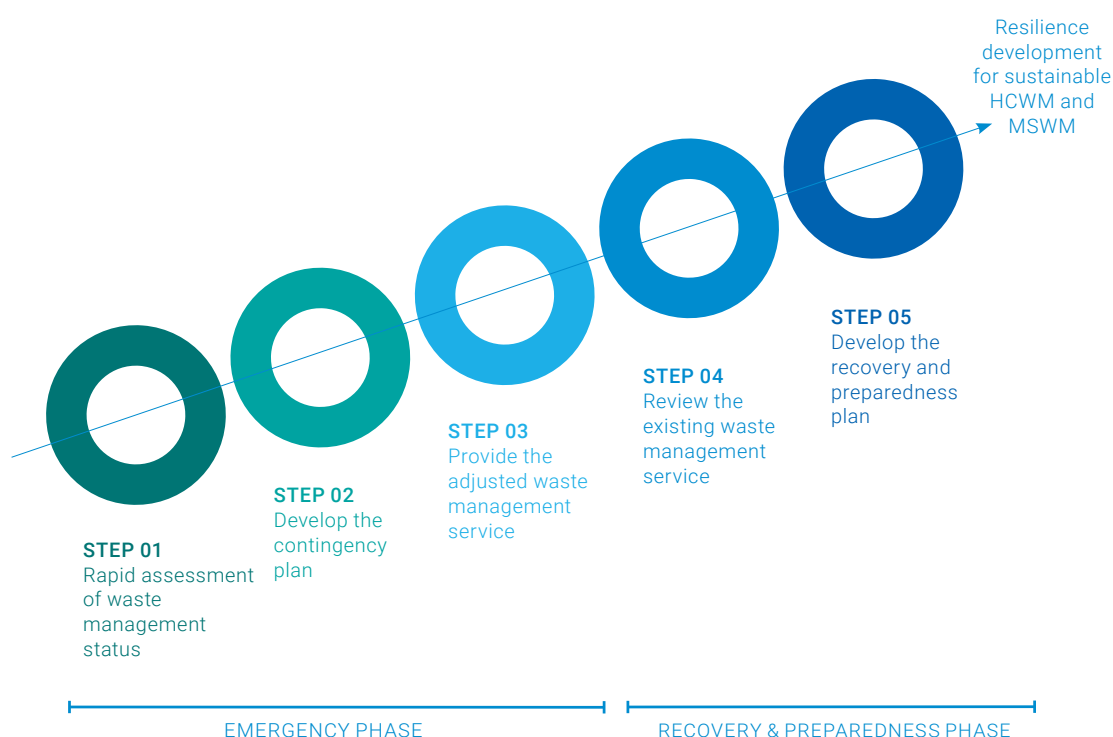
Healthcare waste management options	Widely used methods	Second most commonly used methods	Additional methods
Source Separation	Separate into infectious and noninfectious, liquid, sharp and general waste	Separate using specific colourcoded bins	- Separate at source - Use of properly labelled separate bins - Use double layered bags - Maintain records of separated waste - Disinfection of bags before they are tied
Storage	Use designated storage room	Minimum 3 days storage before collection	- Use cold room - Regular disinfection of storage area - Close, lock and secure storage area - Separate infectious waste from other HCW in the storage room - Minimum 2 days storage before collection - Depute dedicated sanitation workers
Transport	- Use licensed and direct consignment contract with waste treatment - Use of PPE for transportation workers	Use covered vehicles	- Use specific vehicles and equipment used for transport waste - Vehicles are labelled and use GPS tracking and brace systems - Timely and frequent collection and transport - Disinfection of bags/bins prior to loading the vehicle - Keep records of waste transports
Treatment	- Use of incineration - Use of specific landfill sites - Use of autoclaves	Chemical disinfection or highlevel disinfection	- Plasma pyrolysis - Auto or dry heat - Melting - Microwave treatment - Cement kiln - Burning in open container - Deep burial - Open landfill

Source: CCET survey team, 2020

Table 3

Key considerations for making contingency plans

- Consider both short term (emergency response plan) and long term (recovery plan) actions associated with implementing effective healthcare waste management.
 - Carry out a quick survey and map sources of waste generation to identify changes in waste amounts/flows and increase efficient use of resources
 - Maintain an existing waste management system to avoid other health risks due to the service interruptions of waste collection and treatment (Adjust collection service and treatment to manage increased amount of waste)
 - Outreach to increase awareness on source segregation and proper storage/discharge, including double-layer bag use, colored bag use, specific bag distribution, labelling, discharge place, etc.
 - Continue the practice of material reuse and recycle as much as possible, and adjust waste collection and transport systems in response to situation.
- Examine existing treatment and disposal options for infectious waste management and promote the best available options to mitigate transmission risks
 - Permit temporary licensing, long-term storage, inter-municipality collaboration, and transboundary arrangement for proper waste management in a timely manner, etc.
 - Encourage multisectoral cooperation and interaction at all levels
 - Protect lives and livelihoods both of formal and informal sector workers who are involved in waste management system (Occupational Safety and Health (OSH), social safeguards, etc.)
 - Ensure gender equality is taken into account, using gender-disaggregated data, women's participation in decision making and in introducing health and safety measures





Key priority areas that governments should focus on to improve healthcare waste management to prevent the spread of COVID-19 and to develop resilience and preparedness for similar events in the future:

1. Source segregation - Table 4

Waste management methods	General MSW management including potentially infectious one	MSW management for identified quarantine locations with suspected and confirmed COVID-19 positive patients	Healthcare waste management from healthcare facilities
Emergency response phase	• Use double bagged for potentially infectious waste • Separate and keep recyclable materials at the source before being discharged • Cut/destroy used disposable PPE to avoid reuse • Seal the plastic bag when it is two-third full • Awareness outreach for generators (source separation manner, recyclable material concern, stop littering and open burning, etc.)	• Separate infectious waste (contaminated mix waste) including masks, gloves and tissues • Use double bagged for potentially infectious waste • Keep recyclable materials and non-medical hazardous waste (such as e-waste and batteries) for a certain period (until patients are cured) • Awareness outreach for generators (separation of infectious waste with others, stop littering and open burning, etc.). • If cities are finding difficulties in separating waste at source, at minimum it requires to requiring households with COVID19 positive people or people in mandatory quarantine to take precautionary measures when handling their waste, it is appropriate that all citizens are encouraged to follow instructions on safe handling and delivering of waste for collection, in particular package and close a strong bag properly and labelling	• Prepare to use colored containers and/or proper labelling according to the waste categories in each ward • Separate reusable and recyclable materials • Promote use of PPE by workers in healthcare facilities • Provide training for workers in healthcare facilities
Recovery phase	• Refuse/reduce single use plastic (and plastic products) and encourage use of cloth masks as per WHO guidelines • Promote separation at source	• Refuse/reduce single use plastic (and plastic products)	• Secure PPE for preparedness

2. Discharge and collection - Table 5

Waste management methods	General MSW management including potentially infectious one	MSW management for identified quarantine locations with suspected and confirmed COVID-19 positive patients	Healthcare waste management from healthcare facilities
Emergency response phase	- Stop opening of waste bags by waste pickers - Awareness outreach of actions for communities and informal sector, including waste pickers	- Use double-layer plastic bags - Seal plastic bags when they are two-thirds full, and attach a label indicating infectious (contaminated) waste - Disinfect plastic bags - Suspend discharge to the community collection station or outside - Linkage of municipal collection operator with biomedical waste treatment facility operator - Keep infectious (contaminated) waste at source and discharge at specified collection service	- Avoid transport during hours with heavy traffic - Prevent exposure to staff and patients and reduce transport of waste carts through patient care and other clean areas - Avoid collecting general waste at the same time or in the same cart as infectious waste - Secure storage location designated away from patients, public access, and vertebrate pests - Design storage areas well according to waste types - Adopt proper management for sterilization of premises
Recovery phase	- Ensure worker safety and health at all costs by provision of PPE - Awareness and collection of segregated waste into different compartments		Promote the use of premises equipment and a facility for proper healthcare waste management

3. Transportation - Table 6

Waste management methods	General MSW management including potentially infectious one	MSW management for identified quarantine locations with suspected and confirmed COVID-19 positive patients	Healthcare waste management from healthcare facilities
Emergency response phase	- Adjust collection service schedules - Consider temporary licensing to capable waste management service providers - Consider inter-city cooperation - Ban opening of plastic bag for separation (transfer station, etc.) - Provide and instruct workers on the proper use of PPE (collection, transfer station, informal sector, etc.) - Maintain social distance and keep windows open if possible (collection vehicle, transfer station, etc.) - Disinfect collection vehicles - OSH (collection, transfer station, informal sector, etc.)	- Arrange special collection service to collect infectious (contaminated) waste - Consider temporary licensing to capable waste management service provider - Consider inter-city cooperation - Ban opening of plastic bags for separation (transfer station, etc.) - Provide and instruct workers on the proper use of PPE (collection worker) - Transport directly to the treatment facility or disposal site - Maintain social distance and keep windows open if possible (collection vehicle, transfer station, etc.) - Disinfect the collection vehicle - OSH (collection workers)	- Offer regular and increased waste collection services - Possibility of using specialized and licensed healthcare waste service provider should be considered if not yet implemented - Consider temporary licensing to capable waste management service provider - Manifest system - Provide and instruct use of proper PPE for collection workers - Transport directly to the treatment facility or duly authorized disposal site - Maintain social distance and keep windows open if possible (collection vehicle, transfer station, etc.) - Disinfect the collection vehicle - OSH (collection workers)
Recovery phase	- Improve/enhance collection service in normal time - Strengthen operations at transfer stations including waste banks - Improve informal sector involvement	- Arrange a cooperative agreement - Prepare emergency collection schedule, - Secure PPE for preparedness - Improve informal sector involvement	Adapt collection vehicle to transport healthcare waste safely

4. Treatment - Table 7

Waste management methods	General MSW management including potentially infectious one	MSW management for identified quarantine locations with suspected and confirmed COVID-19 positive patients	Healthcare waste management from healthcare facilities
Emergency response phase	- Adjust the treatment schedule according to the increased amount of waste - Consider temporary licensing to capable waste management service provider - Inter-city cooperation - Accept and keep recyclable materials separated - Provide and instruct use of proper PPE for workers - Maintain social distance and open windows in a facility - Disinfect machines and equipment - OSH (formal/informal sectors)	- Treat infectious waste the same as healthcare waste (See healthcare waste management) - Consider temporary licensing to capable waste management service provider - Inter-city cooperation - Accept recyclable materials after a certain period of storage - Provide and instruct use of proper PPE for workers - Maintain social distance and keep windows open if possible, in facilities - Disinfect machines and equipment - OSH (formal/informal sectors)	- Proper healthcare waste treatment methods (non-burnable technologies such as autoclave and incineration) - Best available option (Emergency and/or compromised option (See "3.2. Treatment and disposal methods of healthcare waste" and "4. Conclusion and lessons learnt"), collaboration with cement kiln industry, etc.) - Provide and instruct use of proper PPE for workers - Maintain social distance and keep windows open if possible, in facilities - Disinfect machines and equipment - OSH (workers in a facility)
Recovery phase	- Strengthen informal sector involvement - Promote sustainable intermediate treatment technologies (Recycling, Waste-to-Energy, Co-processing, etc.)	- Strengthen informal sector involvement in consideration of OSH and PPE distribution - Prepare emergency treatment options	Promote proper healthcare waste treatment (autoclave, sterilization, incinerator, disposal, etc.)

5. Final disposal - Table 8

Waste management methods	General MSW management including potentially infectious one	MSW management for identified quarantine locations with suspected and confirmed COVID-19 positive patients	Healthcare waste management from healthcare facilities
Emergency response phase	- Manage final disposal sites (especially in case of open dumpsite) to stop open burning - Stop/restrict waste picking, and provide proper PPE and instructions to waste pickers - Inter-city cooperation	- Treat infectious waste the same as healthcare waste disposal (See healthcare waste management) - Manage disposal site (designate the specific pit, keep out all except authorized persons, no waste picking) - Inter-city cooperation - Provide proper PPE and instructions to for workers on site - Disinfect machines and equipment - OSH (formal/informal sectors)	- Treat infectious waste the same as healthcare waste disposal (See "3.2. Treatment and disposal methods of healthcare waste") - Adapt and manage disposal sites (designate the specific pit, restrict access to unauthorized people, ban waste picking) - Use PPE properly for workers on site - Disinfect the machines and equipment - OSH (formal/informal sectors)
Recovery phase	- Take actions to improve an existing disposal site at short-term - Secured sanitary landfilled as possible at mid and long-termManage disposal site including waste picker involvement	- Prepare for emergency disposal options - Improve disposal sites into sanitary landfills - Develop disposal sites including waste picker involvement	Establish (improve into) sanitary/controlled landfills for healthcare waste



Encourage evidence-based and informed decision making for not only recovery but also building back better. In both the short term and the long term, the actions identified in Tables 4 - 8, for implementing effective healthcare waste management programmes, require multisector cooperation and interaction at all levels. Establishment of a national policy and a legal framework if not already available, training of personnel, and raising public awareness are essential elements of successful healthcare waste management system. Improved public awareness of the problem is vital to encouraging community participation in developing and implementing policies and programmes.

Management of healthcare waste should thus be put into systematic, multifaceted frameworks, and should become an integral feature of healthcare services. The vital role of private waste service provider, the informal sector and women' participation should be considered in designing economic mitigation measures and policies for early recovery.

In addition, the fiscal capacity of municipalities and local service providers should be encouraged to introduce polluter-pays principle, which ensures the availability of waste management services for all.

Policies should be developed and coordinated globally, with the management practices implemented locally. To achieve this aim, IGES Centre Collaborating with UNEP on Environmental Technologies (CCET) and United Nations Environment Programme - International Environmental Technology Centre (UNEP-IETC), in partnership with other international and development partners and respective governments, should work together in developing new insights and knowledge on longer-term policy changes and new ways of working to produce a practical guide which particularly addresses the problems of healthcare waste management in developing countries. In addition, the subject of healthcare waste management can be brought forward into UNEA, thereby encouraging governments to work together in taking actions to establish a proper healthcare waste management system.





1 Introduction

1.1. Overview

The outbreak of coronavirus disease (COVID-19) in late 2019 is far more than a global health crisis. It is affecting our societies and economies and has had a deep impact on our everyday lives. The World Health Organization (WHO) declared the COVID-19 outbreak as a pandemic in March 2020 (WHO, 2020), and the number of victims is still rapidly spreading across the world. Johns Hopkins University reported that the latest number of COVID-19 cases globally is more than 17 million with global deaths of 677,538 (as of 1st August 2020, Johns Hopkins University and Medicine). While protecting lives and recovery of livelihoods are at the core of national and local policies and actions, proper management of waste, including of household, healthcare, and other hazardous waste, is an essential civic service to minimize possible secondary impacts upon health and the environment.

The developing countries that are already lacking adequate waste management practices due to technical, practical, and/or financial constraints are largely vulnerable to waste management difficulties during the pandemic. The waste collection services are further disrupted due to shortage of workers (contracting the virus and entire team workers for self-isolation), lack of safety at work, safe handling of household waste where citizens fall ill with the coronavirus, handling of increased quantities of healthcare waste, and securing safe management of waste from collection points to recycling or treatment facilities. Thus, developing countries and cities are simultaneously fighting against COVID-19, to contain its spread, while at the same time preventing risks to the environment and human health including those of waste workers caused by COVID-19-related waste.

The local level waste management system requires specific precautions, operations, and management practices under the COVID-19 pandemic, in addition to the normal protocols for household, healthcare and other infectious waste management. It is also necessary to have a contingency plan that will promote safe, proper and practical options in a timely and appropriate manner. Although incineration based on well-designed and maintained facilities operating within their design tolerances is a widely accepted and commonly recommended method for treating healthcare waste, most

developing countries do not have access to such advanced incinerators or even the enabling conditions required to operate them safely manner.

In this regard, the Institute for Global Environmental Strategies (IGES) Centre Collaborating with UNEP on Environmental Technologies (CCET) and the United Nations Environment Programme (UNEP) International Environmental Technology Centre (IETC) have jointly prepared this policy report in consultation with policymakers, national experts and key stakeholders in the area of waste management. It reviews the existing practices of waste management, and identifies key challenges and local solutions in the provision of proper management of waste that is generated from healthcare facilities, households and quarantine locations with people confirmed with, or suspected of carrying, COVID-19. It also seeks to identify the best available practices or appropriate technologies that can be immediately and easily adopted in the context of developing countries to minimize potential risks of COVID-19 infection caused by waste management activities. Finally, it gives some recommendations to both policy makers and practitioners in developing countries to improve their healthcare waste management system in the longer term, based on those national and global policies aimed towards achieving a safe and sound waste management systems.

1.2. Scope and target

This report focuses on the management of healthcare waste under the COVID-19 pandemic. It covers healthcare waste generated from hospitals, medical centres and emergency medical facilities, and municipal solid waste (MSW) generated from general households and identified households/quarantine locations with suspected and confirmed COVID-19 positive patients. Based on the waste hierarchy, it reviews the flow of healthcare waste management, including waste separation at source, discharge or handling at source, collection, transportation, recycling and final disposal. The main audience for the report includes decision-makers and practitioners in national and local governments, private and informal service providers, development agencies, academics and think tanks that are involved in healthcare waste management in developing countries.

1.3. Objectives

The report aims to review the existing practices of healthcare waste management under the COVID-19 pandemic and to identify best available or appropriate waste management practices that are operationally and technically in line with local conditions. This will include regulatory frameworks, human resources, infrastructure, and financial constraints, while also considering the importance of other impacts on the environment and human health from waste management. COVID-19 waste management may require specific capacities, precautions, equipment, facilities, operations, and management in addition to the common protocols for healthcare waste management. The report thus provides some recommendations, particularly for developing countries, on what options are suitable and available, and how to adapt existing protocols and practices for COVID-19 in a practical manner at both emergency and recovery stages.

1.4. Methodology

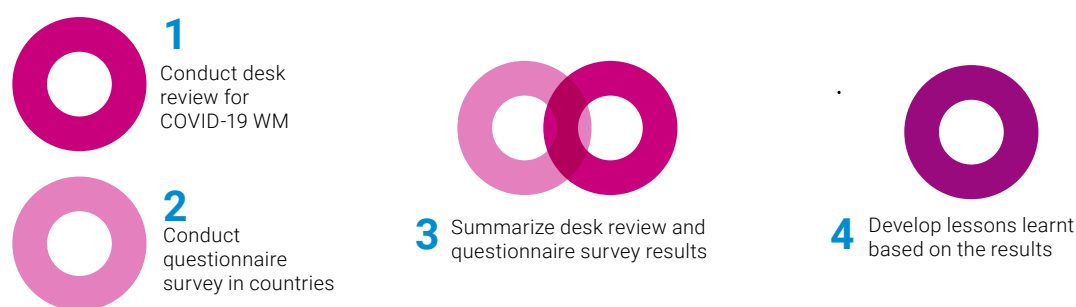
The report presents a comprehensive source of information on healthcare waste management under the COVID-19 pandemic, which can be further utilized for the development of national and local policies, guidelines and manuals, strategic plans, or contingency plans in order to protect people and communities, and develop resilience, based on their local contexts, towards achieving sustainable healthcare waste management in developing countries. The relevant data and information were collected by applying both desk review and country surveys (Figure. 1).

A desk review of existing documents related to healthcare waste management was carried out using Google and global e-libraries. This prioritized official document published after the year 2000 (See Table 9 and supplementary material (<https://www.ccet.jp/publications>)). Thirteen publications issued by international or development agencies, such as

Table 9 - A list of documents reviewed in the study

	Guideline	Factsheets	Policy/ Strategy	Flowchart	Q&A	Recomm- endations	Notifications	Research/ Documents	Manual	Flyer	Regulation	Standards	Act
INTERNATIONAL AGENCIES													
ADB						2020							
ACR+				2020									
Secretariat of the Basel Convention	2003				2020								
CDC, US	2019												
ISWA						2020							
Stericycle			2020										
SWANA	2020												
UNEP		2020											
UN-Habitat	2020												
WHO	2014, 2017, 2020												
COUNTRY-SPECIFIC													
China						2020	2020						
Ethiopia	2005, 2011												
India	2020					2016							
Japan	2009				2020	2020a, 2020b, 2020c		2018	2020a, 2020b				
Kenya	2010		2007								2006, 2012, 2020		
Malaysia	2005, 2009							2013, 2017, 2020					
Mexico	2020											2003	
South Africa	2020		2020				2013	2020			2004		2007
Sri Lanka	2020a, 2020b												

Figure 1 - Flowchart of methodology



Source: Compiled by Authors, 2020

United Nations Agencies, WHO, the World Bank (WB), the Asian Development Bank (ADB) and the International Solid Waste Management Association (ISWA) were found, as well as 32 country-specific policy documents related to healthcare waste management. These are made up of different types of documents such as guidelines, policies, acts, manuals, regulations, strategies, factsheets and flyers, as summarized in Table 9. Within these resources, guidelines represent a large portion, and most of them were issued by international agencies and respective governments before the COVID-19 pandemic.

A questionnaire-based country survey was conducted as to supplement to the desk review. The survey questionnaire was focused on three main areas: (1) policy and institutional setting for healthcare waste management, (2) statistics on healthcare waste generation and (3) healthcare waste management practices. It also looked at any changes made by governments to the policy and practice of waste management due to COVID-19 pandemic. Members of CCET, UNEP-IETC and UNEP regional and country offices, the South Asia Co-operative Environment Programme (SACEP), and the Centre for IMT-GT Subregional Cooperation (CIMT) solicited the survey responses. Experts in the respective countries responded to the questionnaire survey during the period of April to May 2020, with answers based on their networks among local stakeholders in their respective regions and countries, and counterparts that included national and local governments, academia, NGOs and international organizations. Questionnaire responses were received in a timely manner from 15 countries from Asia (Afghanistan, Bangladesh, China, India, Indonesia, Japan, Malaysia, Nepal, Sri Lanka, Thailand), Africa (Ethiopia, Kenya, South Africa), and Latin America and the Caribbean (Mexico, Saint Lucia). The detailed result of the questionnaire survey, together with the country-specific documents, are compiled in supplementary material (<https://www.ccet.jp/publications>).

The report includes the following four sections and annex:

- **Section 1** includes the introduction, background and key priorities.
- **Section 2** contains the results of the data analysis which are summarized and divided into four parts: 1) Characterization of healthcare waste, 2) Volume of healthcare waste generation, 3) Policy and regulatory aspects, and 4) COVID-19 and gender in waste management. Here, a desk study was performed and augmented by questionnaire survey responses received from developing countries (Supplementary material).
- **Section 3** summarizes the practices of healthcare waste management (healthcare waste management flow) in greater detail under four sub-headings: 1) Waste segregation, storage, and transportation, 2) Treatment and disposal methods of healthcare waste, 3) Occupational safety and health, and 4) Capacity building and awareness raising.
- **Section 4** contains conclusion and lessons learnt from the review and survey results are compiled under six priority areas, including 1) Policy, regulatory and institutional framework, 2) Safe handling of infectious waste, 3) Appropriate treatment and disposal methods, 4) Capacity development and awareness raising, 5) Data management, statistics, and learning, and 6) General principles and guidance for managing infectious waste under the COVID-19 pandemic.
- **Annex** contains documentation of three case studies: Indonesia, Kenya, and Sri Lanka.

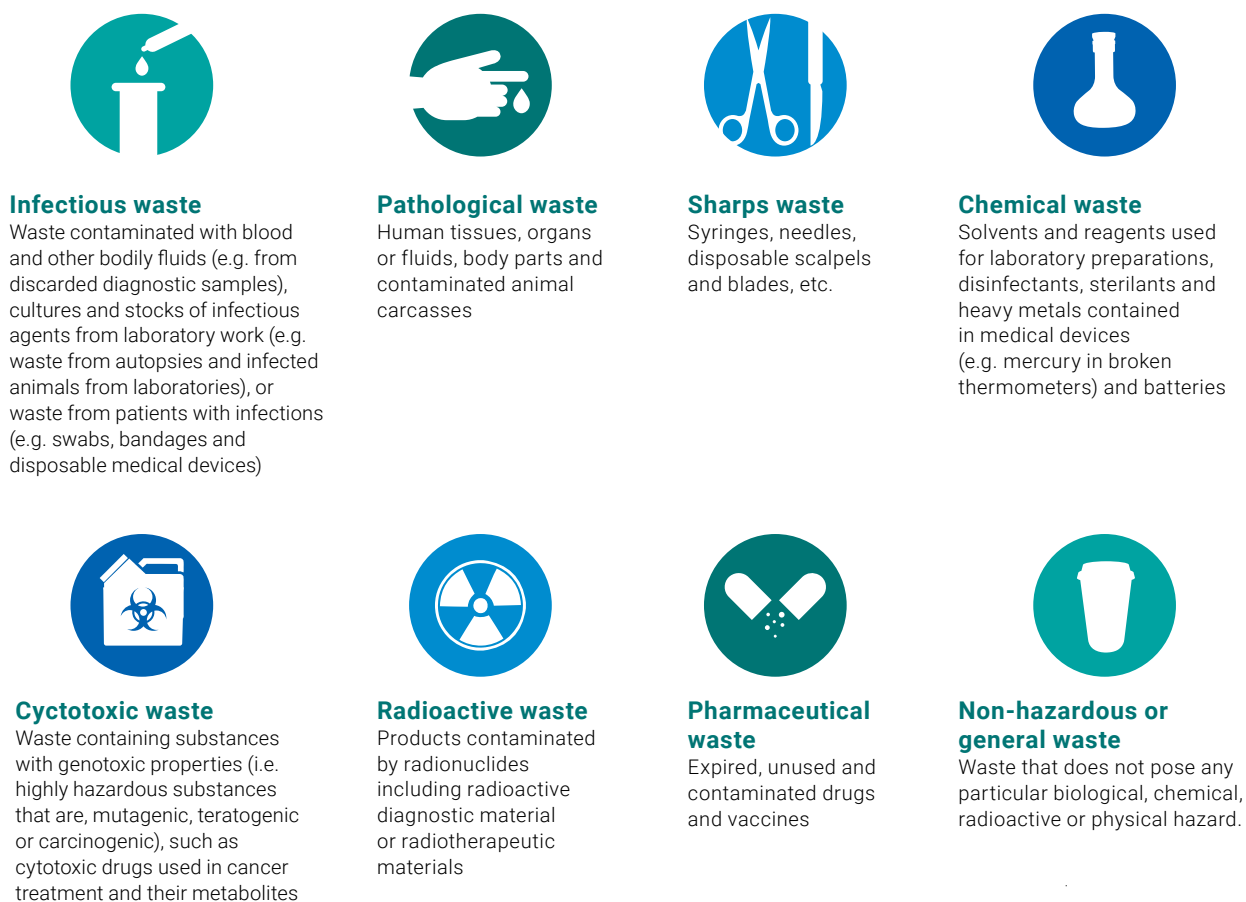


2 Statistics, Policy and Regulatory Aspects in Managing Healthcare Waste under COVID-19

2.1. Characterization of healthcare waste

According to the WHO guideline reports (WHO, 2014; WHO, 2017), healthcare waste includes all the waste generated within health-care facilities, research centers and laboratories related to medical procedures. It also includes the healthcare waste generated at homes (e.g. home dialysis, self-administration of insulin, recuperative care). The healthcare waste can be categorized into eight major groups, including both hazardous and non-hazardous components, as shown in Figure 2.

Figure 2 - Classification of healthcare waste

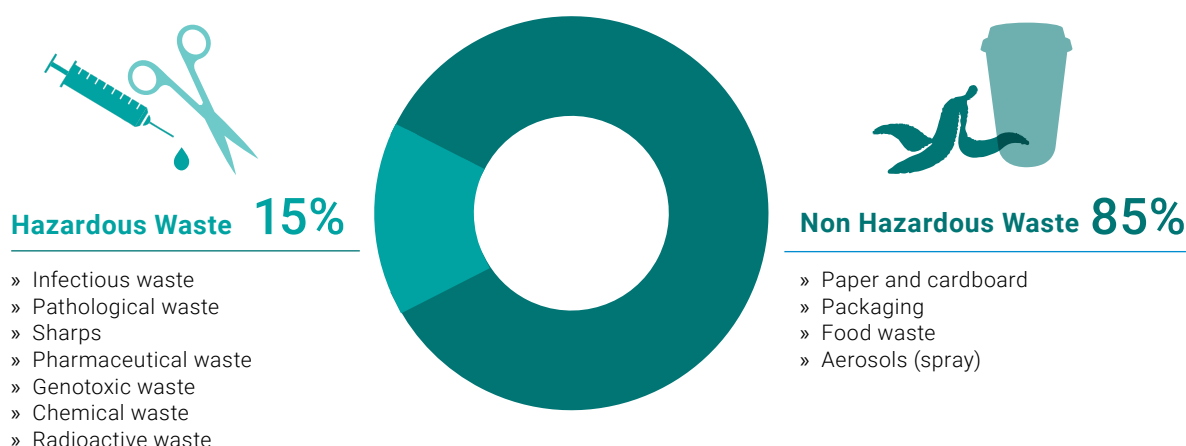


Source: Compiled by Authors based on WHO, 2014

The Compendium on Technologies for the Treatment/ Destruction of Healthcare Waste (UNEP-IETC, 2012) also provides baseline information on healthcare waste composition and amount, including potentially infectious contents. Waste generated in healthcare facilities is generally reported as approximately 85% non-hazardous waste and 15% hazardous waste (Figure 3).

However, the data gathered from the questionnaire survey found that this percentage of infectious or hazardous waste and non-hazardous or general waste might differ from country to country and city to city, as shown in Table 10. Even though no data are readily available to fully understand the COVID-19 pandemic, it can be expected that the hazardous waste component may be increased further due to the COVID-19 waste from medical sectors and domestic waste management.

Figure 3 - Distribution of hazardous and non-hazardous components in healthcare waste.



Source: Compiled by Authors based on UNEP-IETC, 2012

Table 10 - Composition of healthcare waste

Name of the Country or City	Composition of healthcare waste (%)	
	Hazardous	Non-hazardous
NATIONAL LEVEL		
India	10-25	90-75
Kenya	15	85
Malaysia	20	80
Nepal	27	73
CITY LEVEL		
Dhaka City (Bangladesh)	18	82
Surabaya (Indonesia)	27	73
Pangkal Pinang (Indonesia)	10-30	90-70
Padang (Indonesia)	20	80

Source: Compiled by Authors based on the country survey

In addition to material constituents, an understanding about the properties of healthcare waste is required to properly select suitable options for managing healthcare waste, identifying treatment technologies, and setting necessary parameters for operation of treatment systems. The moisture content, heating value, percentage of

combustible materials, and bulk densities of healthcare waste in general conditions are summarised in Table 11, based on the UNEP-IETC's data (2012). However, these parameters may be changed in the current situation due to the COVID-19 pandemic.

Table 11. Key properties of healthcare waste.

Parameter	Average value
Moisture content	15% by weight
Energy value (heating)	15 MJ/kg (3,600 kcal/kg or 6,400 BTU/lb)
Combustion residues	15% by weight
Bulk density	100 – 200 kg/m ³

Source: UNEP-IETC (2012)

2.2. Volume of healthcare waste generation

The average healthcare waste generation rates by type of medical facility under normal conditions are shown in Table 12. According to this information, the highest generation of healthcare waste happens in maternity centers and hospitals.



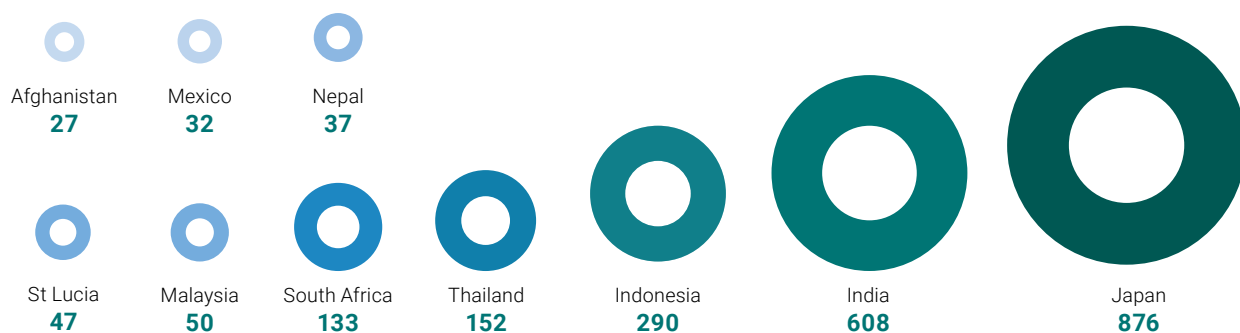
Table 12. Average waste generation rates by type of facility.

Facility	Total Healthcare Waste Generation Rate	Infectious Healthcare Waste Generation Rate
Hospital	2 kg/bed-day	0.5kg/bed-day
Clinic	0.02 kg/patient-day	0.007 kg/patient-day
Maternity Center	5 kg/patient-day	3 kg/patient-day
Clinical Laboratory	0.06 kg/test-day	0.02 kg/test-day
Basic Health Unit	0.04 kg/patient-day	0.01 kg/patient-day

Source: UNEP-IETC (2012)

Although there is a limitation on national data availability and its accuracy, Figure 4 shows healthcare waste generation in survey countries compiled based on the questionnaire survey.

Figure 4. Amount of healthcare waste generation (Tonnes per day) in selected countries



Source: Compiled by authors based on the country survey

In terms of healthcare waste generation during the COVID-19 pandemic in developing countries, Table 13 shows a possible increase in healthcare waste volumes in selected five cities in Asia (ADB, 2020). It is also estimated that the increase of healthcare waste from healthcare facilities associated with COVID-19 is 3.4kg/person/day.

Table 13. Estimated additional amount of HCW in each city due to the COVID-19 pandemic. Source: ADB, 2020

City	Population (World Population Review)	healthcare waste generated (tonnes/day before COVID-19)	Estimated additional healthcare waste generation (tonnes/day during COVID-19)	Percentage of increase due to COVID-19
Manila	14 million	47	280	496
Jakarta	10.6 million	35	212	506
Kuala Lumpur	10.5 million	35	210	500
Bangkok	8 million	27	160	493
Ha Noi	7.7 million	26	154	492

In addition, the following estimates of healthcare waste generation during the COVID-19 pandemic from healthcare facilities, households, and public places were compiled based on the questionnaire survey carried out for this report.

- Approximately 2.5 kg/bed/day of COVID-19 healthcare waste is being generated in developing countries based on the findings of 2.85 kg/bed/day in Thailand, 2.23 kg/bed/day in Indonesia and 2.0 - 2.2 kg/bed/day in Mexico.
- Estimate that healthcare waste treatment capacity was required from 50 tons/day to 106.9 tons/day, during the active pandemic in Wuhan, China.
- A rapid increase of healthcare waste generation in West Java, Indonesia during the COVID-19 epidemic, including about 10,903, 11,646 and 14,606 tonnes of healthcare waste generation in the months of January, March, and April 2020 respectively, with an increase of about 30% between January and April.
- After Japan declared a state of emergency on 7 April 2020, Tokyo's collected commercial waste amount decreased by 57%, while household waste amount increased by 110% in May 2020 as compared to the previous year (Kankyo business online on 4th June 2020)
- Infectious waste generated from households and public places during the COVID-19 pandemic includes potentially contaminated materials such as masks, gloves, tissues, disposable clothes and used and expired medicines. However, none of the documents or survey responses we reviewed contained quantitative information on amounts of COVID-19 waste contained in domestic or MSW.
- Since many cities and/or health care institutions may not have the capacity to deal with the projected excessive amounts of healthcare waste, contingency plans based on local constraints should be developed.

2.3. Policy and regulatory aspects

National, provincial, and municipal governments with existing healthcare waste management plans and policies will benefit greatly from using these plans and policies in their response to COVID-19 waste. Within the municipal solid waste sector, existing contingency plans for disaster waste, particularly those including healthcare waste, can

also be useful in the context of COVID-19. For municipalities or countries who do not have existing strategies, plans or policies, when they are developed, they should include contingency planning for epidemic situations, and this content can be informed by ongoing local COVID-19 waste management challenges.

A review of existing national legislation addressing healthcare/medical waste

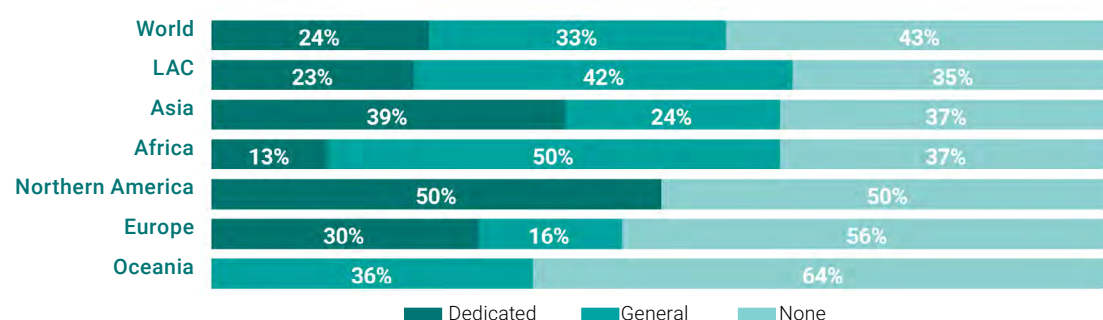
Globally, there are 168 national laws and regulations (henceforth, for simplicity, referred to jointly as “laws”) that address or mention healthcare waste management, of which 57 relate only to healthcare waste streams, while the other 111 address multiple waste streams. There is an important distinction here, because the laws often address waste across the board, and may list a number of different waste streams, but generally without substantive content, which poses a problem for the methodology used to collect the data¹. Thus, laws addressing a single waste stream are generally more substantial than a law that broadly covers several, with a few exceptions.

Looking at Figure 5, we can see that only just over half of the countries in the world have any form of legislation in place regarding healthcare waste management, and only about a quarter have dedicated laws. Over 80% percent of the global population is covered by healthcare waste management legislation. Although this percentage seems relatively high, nonetheless the remaining ‘uncovered’ portion of the world population comprises over a billion people. Another notable result is that Europe, which is usually the region with the most legislation related to specific waste streams, has a rather low coverage of dedicated laws on healthcare waste management.

The fact that legislation exists does not necessarily mean that it is extensive, sufficient, or enforced. For instance, general laws may list healthcare waste as a component of hazardous waste, which is technically

correct, but often neglects to account for the fact that management of different hazardous waste streams differs greatly. Similarly, laws may not be enforced for various reasons, and the informal waste sector often works without regulation outside the law. For example, Indonesia has a Law on Solid Waste (2008), as well as Environmental Health Standards for Hospitals (2004) including healthcare waste, but these both often lack practical application. Additionally, even if there is national legislation, this does not guarantee nationwide coverage. Compliance may also be limited to urban areas due to lack of infrastructure in rural areas, for example general waste collection rates for rural areas in low- and middle-income countries is roughly half of that in urban areas. On the other hand, even though many countries, including the majority of Europe, may be lacking legislation on healthcare waste, this does not mean that the waste stream is untreated. Healthcare waste treatment might be addressed through guidelines, strategies and/or policies, which were not included in the scope of this study. Additionally, some countries also have regional or state legislation, such as in Belgium, Germany and Spain, and are thus not captured in this database of national legislation. Though it is outside the remit of this desk study to make any conclusions on how well existing laws operate, the analysis shows that there is a coverage gap globally in terms of healthcare waste management legislation. This gap may be relevant to consider both during the COVID-19 epidemic, and more generally for disposal of contaminated and infectious waste.

Figure 5 - Percentage of countries per region with adopted legislation on Healthcare Waste Management



¹ The database used for the legislation data and analysis is based on existing and adopted national waste legislation available online, and thus additional legislation may exist. Repealed laws and regulations are excluded, as are policies and strategies due to how widely these may differ between nations in terms of their status, and in order to ensure a robust and pre-defined methodology for the data collection. Legal texts have not been analyzed in full, a pre-defined string of keywords have been used to categorize each law based on which waste stream(s) it addresses. Main data sources include e, Library of Congress law library, e, the WorldLII law library, as well as national online law repositories on government websites.

In addition to the existing national policies and plans, most countries that are part of the questionnaire survey in this study immediately issued some policies, guidance and plans to respond to the COVID-19 pandemic, as shown in

Table 14. As in any emergency, in times of COVID-19 it is essential to ensure clear assignment of responsibility, as well as sufficient human and material resources to safely dispose of COVID-19-related waste.

Table 14. Guidance, plan and notice associated with COVID-19 waste management.

Country (City)	Practices for COVID-19 waste generated from healthcare facilities
Afghanistan	The Ministry of Public Health of Afghanistan issued two national plans: (i) Preliminary Stakeholder Engagement Plan (SEP), March 2020; (ii) Environmental and Social Commitment Plan (ESCP), March 2020.
China	The Ministry of Ecology and Environment of the People's Republic of China issued: (i) Notice on Environmental Management of Medical Waste Caused by COVID-19, January 2020; (ii) Notice on Issuing the Work Plan for Comprehensive Waste Management in Medical Institutions, February 2020; (iii) Notice on the Management of Medical Waste in Medical Institutions for COVID-19, January 2020; (iv) Guide on Management and Technical on Emergency Treatment and Disposal of Medical Waste Caused by COVID-19, January 2020.
India	In addition to the existing Biomedical Waste Management Rules (2016), (i) Guidelines for Handling, Treatment, and Disposal of Waste Generated during Treatment/Diagnosis/Quarantine of COVID-19 Patients were issued by the Central Pollution Control Board (CPCB); (ii) Individual State Pollution Control Boards provides more detailed guidelines for concerned stakeholders in their respective states.
Indonesia	The overall coordination of COVID-19 issues is under the National Disaster Control Agency. However, the Ministry of Environment and Forest (MOEF) enacted: (i) a Letter #S.167/MENLHK/PSLB3/PLB.3/3/3030 concerning the Handling of HCW in the health facilities in the emergency for COVID-19; (ii) a waste generated from COVID-19 handling is classified as hazardous waste, under the GR #101/2014 law; (iii) a Circular Letter #SE.2/MENLHK/PSLB3/PLB.3/3/2020 for the Handling of infectious waste and household waste for Covid-19 waste handling; (iv) a special letter from Directorate General of Waste and Hazardous Waste Management of MOEF sent to a private company of transportation, treatment and disposal regarding healthcare waste management in emergency conditions covering COVID-19 waste.
Japan	Ministry of Environment, Japan (MOEJ) notified all local governments to confirm the existing guidelines and manuals for healthcare waste to manage COVID-19 waste.
Kenya	Ministry of Health issued both the Safe Management and Disposal of Safety Product in Prevention of Spread of COVID-19 and the Interim Infection Prevention and Control Recommendations for Coronavirus Disease 2019 (COVID-19) in Health Care Settings.
Mexico	Government of Mexico issued a guideline for better practices of COVID-19 prevention while handling municipal solid waste.
Nepal	The Health Emergency and Disaster Management Unit of the Ministry of Health and Population has issued a number of interim guidance documents: (i) Interim Guidance for Extension of COVID-19 and Other Health Services, 2020; (ii) NMC Interim Guidance for Infection Prevention and Control when COVID-19 is suspected; (iii) Interim Clinical Guidance for Care of Patients with COVID-19 in Health Care Settings; (iv) COVID-19 Clinical Management Guideline; (v) Guidelines for use of PPE -COVID-19; (vi) COVID-19 Dead Body Management Guidelines; (vii) SOP for cleaning and decontamination of ambulance.
South Africa	The COVID-19 National Public Hygiene Strategy and Implementation Plan developed by the National Department of Health, 2020. Waste management response to COVID-19 pandemic in South Africa Western Cape perspective, 2020
Sri Lanka	Interim Guideline for Management of Solid Waste Generated by Households and Places under Self-Quarantine due to COVID-19 Outbreak issued through Letter No. PL/7/1/18/1.
Thailand	(i) Guidelines from Department of Health for: Cleaning staff; Local Governments; Waste Transporters; and Waste Disposal Facilities; (ii) Ministerial Letter of Ministry of Environment and Forestry No. SE.2/MENLHK/PSLB3/PLB.3/3/2020 tentang Pengelolaan limbah infeksius (Limbah B3) dan sampah rumah tangga dari penanganan Corona virus disease (COVID-19); (iii) Ministerial Letter of Ministry of Environment and Forestry No. S.167/MENLHK/PSLB3/PLB.3/3/2020.

Source: Compiled by authors based on country survey, 2020



According to the above information, the issue with many developing countries is in not only developing policies and issuing guidance, but also how to enforce them after preparation. A national healthcare waste management policy is thus required to drive political decision making and mobilize government efforts and resources for successful implementation of the plans (WHO, 2014; UNEP, 2020). Some of the key elements to be considered for inclusion in healthcare waste management policies include:

- **Identification of needs and gaps in the country**, considering international agreements and conventions adopted nationally, sustainable development and environment and safe management of hazardous waste. (Figure 6)
- **Regulations** specifying HCW management such as waste segregation, collection, storage, handling, treatment, disposal and transport of different waste categories, responsibilities, and training requirements.
- **Practical/technical guidelines** and manuals supplementing the official regulations on implementation, directly applicable to local managers and staff.
- **Regularly updated allocation of roles**, resources, and responsibilities, describing actions to be implemented by authorities, healthcare personnel, and waste workers.
- **A contingency plan** for use during emergencies to ensure continuity of healthcare waste management services. During emergency situations, resources

may be limited, so contingency plans should involve alternative solutions for personnel, vehicles, infectious waste, accumulation of waste, washing, disinfection and street cleaning services. The contingency plans should address the following questions:

- » What standards will be used to guide a response?
- » What are the current capacities of the agencies or organizations to respond?
- » What initial assessment arrangements are needed?
- » What actions will be taken as an immediate response to the situation?
- » Who does what and when?
- » Who is coordinating and leading?
- » What resources would be needed?
- » How will information flow between the various levels (local and national)?
- » Have specific preparedness actions been agreed on and practiced?

In addition, provision of MSW management is a critical service that should operate continuously under pandemic conditions. Disruption in daily MSW management service will cause additional social and public health issues, which must be avoided. COVID-19 waste generated from households and public places can potentially be managed according to existing policies, regulations, strategies, and plans. Specific notifications and operations for such waste have been developed in some countries.

Figure 6 - Hierarchy of the regulatory and institutional framework for healthcare waste management.



Source: WHO (2014)



In Japan, local governments and waste management service providers have emphasized continuity of proper MSW management service including the development of contingency plans, preparation of necessary PPE for waste management workers, as well as outreach and training activities for citizens and major waste generators.



In Sri Lanka, an interim guideline for MSW generated by households and places under self-quarantine due to COVID-19 outbreak was formulated. (See "Annex: Case studies, Sri Lanka")

2.4. COVID-19 and gender in waste management

There is still little gender-disaggregated data on waste and COVID-19. However, there are many underlying factors which suggest that the COVID-19 pandemic will put women at a higher health, social and economic risk² and potentially exacerbate existing gender inequality. Although waste management is often considered gender-neutral, gender inequalities, responsibility and roles are deeply embedded in many aspects of waste management. Therefore, it is important to recognize the relationship between gender and waste in the context of COVID-19. The UNEP-IETC's publication, *Gender and waste nexus: Experiences from Bhutan, Mongolia and Nepal* (2019), co-authored with GRID-Arendal, highlights the division of labour in waste management based on conventional gender roles and responsibilities. In both the public and private sectors, men hold most upper-level decision-making positions, from city managers and planners to landfill operators and managers of waste collection companies, while women are more engaged in household and community activities related to waste, which are typically unpaid or minimally compensated. These responsibilities may expose women to higher risks of infection during the COVID-19 pandemic, unless women receive an opportunity to learn how to safely manage infectious waste in households and the community.

Globally, an estimated 20 million people rely on informal waste recycling for their livelihoods³. In Asia, for example, women as well as children are an integral part of informal waste sector, making their living from waste collection and/or recycling. Indeed, the study found that more women than men tend to work in the informal sector in Bhutan, Mongolia and Nepal, where they often perform duties with limited or no safety equipment, and for low remuneration, such as waste picking at landfills. Hence, due to the COVID-19 pandemic, women may be put at a considerable risk when infectious waste is dumped at disposal sites. While cultural factors may exclude women from the decision-making process and restrict their access to information on outbreaks and availability of services, it is important to ensure that women are able to get appropriate information about how to apply precautionary practices such as using PPE, as well as access health services and insurance to ensure their health and safety. The study further points out that, within the informal sector, women are often limited to lower-income tasks, such as waste picking, sweeping and waste separation, whereas men are able to assume positions of higher authority, dealing with the buying and

reselling of recyclables, for example. Throughout the formal waste economy, too, women are typically excluded from higher-income and decision-making positions. If the COVID-19 pandemic continues, it may pose a serious economic threat to women in the waste sector and could increase gender gaps in livelihoods.

The study also indicates that existing waste management policies and guidelines are gender blind. This means that many guidelines fail to address specific needs and issues related to gender, despite the reality that women are usually the primary handlers of household waste and that a clear gender division of labour exists in the waste sector. Mainstreaming gender in the waste sector could represent an opportunity to improve waste management in a more resilient and sustainable manner. Households, for example, which currently have the least formal engagement in the waste sector's guidance and policy structures, have tremendous collective capacity to reduce the flow of waste into the waste management systems. Women, as well as men, can play a valuable role not only in accelerating waste reduction, segregation, composting and recycling in general, but also to ensure safety through the appropriate segregation of waste at the household level during the COVID-19 pandemic.

- **Collection of gender-disaggregated data:** Gender disaggregated data related to waste and the COVID-19 outbreak will help in understanding the gendered differences in exposure to infectious waste and designing gender-responsive regulations and guidelines in response to the COVID-19 pandemic.
- **Women's representation:** Support women to be part of the decision making process and increasing the representation of women in decision-making positions in waste management could help to ensure that women also have an opportunity to shape important waste management decisions.
- **Health and safety:** Cultural factors may exclude women from the decision-making process and restrict their access to information on outbreaks and availability of services. Therefore, it is important to ensure that women are able to get appropriate information about how to apply precautionary practices such as using PPE when handling healthcare and infectious waste, as well as to access health services and insurance to ensure their health and safety.

² Interagency Standing Committee (undated) available at <https://interagencystandingcommittee.org/system/files/2020-03/COVID-19%20-%20How%20to%20include%20marginalized%20and%20vulnerable%20people%20in%20risk%20communication%20and%20community%20engagement.pdf>

³ OECD (2001) Available at <https://www.oecd-ilibrary.org/sites/9789264256385-9-en/index.html?itemId=/content/component/9789264256385-9-en>



3 Current Practices of Healthcare Waste Management

3.1. Waste segregation, storage, and transportation of COVID-19 waste

Proper segregation of healthcare waste at source, storage, and transportation are required not only to prevent negative health and environmental impacts, but also to maintain resource efficiency and material recovery. In addition, existing operational protocols for healthcare waste management and MSW management should be continued for COVID-19 waste, with specific precautionary measures, adjustments, and arrangements applied to mitigate any potential risks of COVID-19 infection in the waste management process. The following key findings (Table 15) have been identified through the desk study and questionnaire survey in handling the healthcare waste from healthcare facilities.

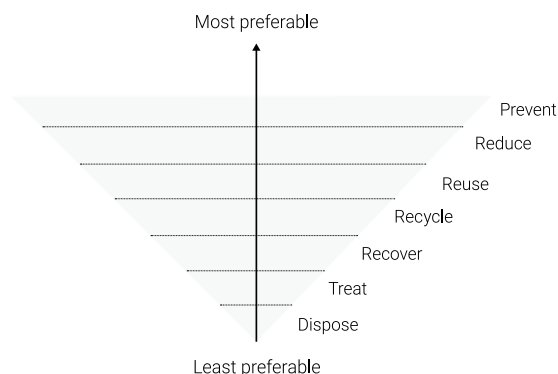
Waste minimization

According to the waste-management hierarchy (Fig 7) based on the concept of the 3Rs (reduce, reuse and recycle), better practice of healthcare waste management should aim to avoid or recover as much of the waste as possible, rather than disposing of it by burning or burial. The most preferred management solution is not to produce the waste in the first place, by avoiding wasteful ways of working. Although waste minimization is widely practiced at the point of its generation, such as separation of hazardous waste from other wastes, a proper plan that adopts purchasing and stock control strategies can also result in a reduction in the amount of waste produced.

Waste segregation at source

Colour coding makes it easier for staff who are handling waste to put waste items into the correct container, and to maintain segregation of the wastes during transport, storage, treatment and disposal. Colour coding also provides a visual indication of the potential risk posed by the waste in a particular container. Many countries have national legislation that prescribes the waste segregation categories to be used and a system of colour coding for waste containers. Where there is no national legislation, a World Health Organization (WHO) scheme is available (Table 16). Each country has issued some specific regulations, operations and recommendations for proper waste segregation and

Figure 7 - Waste Management Hierarchy



Source: WHO, 2014

handling at source that includes COVID-19 waste generated by healthcare facilities, as shown below:

- Segregate waste as close to the source as possible (proximity principle)
- Place segregated waste in identifiable, color-coded, labelled containers or bags, which are leak-proof and puncture resistant (particularly for sharps)
- Place instructions for proper waste segregation close to the container
- Use double-layer bags. Waste is to be placed in a specialized bag or container, sealed, and then placed in the second bag or container

In-house transport and storage

Onsite transport should take place during less busy times whenever possible. Set routes should be used to prevent staff and patients from being exposed, and to minimize the passage of loaded carts through patient care and other clean areas. Regular transport routes and collection times should be fixed and reliable. General waste should not be collected at the same time, or using the same trolley, as infectious or other hazardous waste. Storage should be located away from patients and public access. It should also be secured properly ventilated and inaccessible to vertebrate pests. Transport staff should wear adequate personal protective equipment, gloves, strong and closed shoes, overalls and masks.

Table 15 - Existing practices for healthcare waste separation, storage and transportation in selected countries

Country	Practices for COVID-19 waste generated from healthcare facilities
Afghanistan	- Separate healthcare wastes such as general waste, anatomical waste, and other infectious waste at the point of generation - Collect sharps (used auto-disable syringes) separately in yellow boxes - Designate a storage area at healthcare facilities (separated wastes from each ward are transported by wheeled trolleys) - Transport safely packed waste with adequate labeling for off-site treatment and disposal
Bangladesh	- Use separate color-coded bins (Black: Non-hazardous waste, Red: Sharp waste, Yellow: Infectious/pathological waste, etc.) - Store the bins on their premises, to be collected mostly on a daily basis, by separate covered vehicles, for transportation to a treatment site
India	- Use dedicated trolleys and collection bins in COVID-19 isolation wards - Waste contaminated with blood / body fluids of COVID-19 patients to be collected in yellow bag for home quarantined households. - Paste a label "COVID-19 Waste" on these items - Disinfect with 1% sodium hypochlorite solution daily on (inner and outer) surfaces of containers/bins/trolleys - Depute dedicated sanitation workers separately for biomedical waste and general solid waste collection and timely transfer to temporary storage - Use a vehicle with GPS and barcoding systems for bag/containers containing HCW for waste tracking, as well as having label of 'Biohazard' or 'Cytotoxic' on the vehicle
Indonesia (some local governments)	- Identify the means of classification and communication (symbols, labels) - Designate COVID-19 infectious bins - Conduct internal sterilization/disinfection before bags are tied - Disinfect bags before collection - Label bags "Danger, do not open" - Schedule the transportation of waste by the cleaning service every day on weekdays
Japan	- Separate infectious, non-infectious, and general wastes - Separate sharps from other infectious wastes with a proper container - Seal the container, which is easy to use and hard to break - Transport by a designated cart to avoid scattering and spilling wastes within a facility - Use short storage periods as much as possible - Separate infectious wastes and store from other wastes in the storage room - Access to the storage room only by authorized persons - Apply clear labelling, with notification given on bags for infectious wastes at the storage room
Kenya	- Place infectious waste in yellow bins with liners marked "Danger Hazardous Medical" - Never sort through contaminated wastes - Reuse reusable items only after proper disinfection - Tie bags when they are 2/3 full, and disinfect the waste and place it in a designated area for collection - Store waste in specified areas with restricted access
Malaysia	- Not separate COVID-19 waste with other infectious waste - Equip the cold room in some bigger healthcare facilities - Collect daily or 3 times a week depending on the quantity - Transport only by a special lorry licensed to transport hazardous waste
Mexico	- Same protocol with other infectious waste according to the Mexican Standard #087) - Use a container hermetic and polyethylene bag according to the type of healthcare wastes - Use the bag with translucent red polyethylene of minimum caliber 200 and translucent yellow color of minimum 300 gauge, waterproof, and with a heavy metal content of not more than one parts per million (PPM) and free of chlorine - Fill to 80% of the capacity of the bag, and close and transport to the temporary storage site - Mark with the universal risk symbol and the legend biological - Designate the temporary storage of waste biological-infectious dangerous. - Stored biological-infectious hazardous waste separated from the patient areas, and medicine warehouse, etc., accessible for collection and transport without risks of flood and entry of animals, with signs alluding to their dangerousness, access only responsible personnel - Not compact hazardous biological-infectious during its collection and transportation - Use the collection vehicle with closed box and hermetic vehicle and operate with cooling systems to keep residues at a maximum temperature of 4 °C (four degrees Celsius) and with mechanized loading and unloading systems - Must not be mixed with any other type of municipal or industrial origin during transportation, hazardous biological-infectious waste
Nepal	- Designate waste storage in health facilities (some meet standard, but some are unmanaged) - Use specific trollies for transportation within the hospitals - Use specific vehicles for transportation from healthcare facilities to treatment WMSPs
South Africa	- Minimize the volume of HCW at source - Remove ¾ full sealed box sets, and store at the central storage area prior to collection for treatment and disposal - Secure space with the sign of "Suspected COVID-19" - Storage on site in a following manner: secure sufficient capacity, prevent access to these areas to unauthorized persons, mark with warning signs on, or adjacent to, the exterior of entry doors, gates, or lids, secure by use of locks on entry doors, gates, or receptacle lids, and prevent odour - Use plastic bags with a capacity of 60 liters or more, and at least 80 microns in thickness - Ensure that the time between collection of a consignment by a transporter from the relevant generator's premises and the treatment of that health care risk waste does not exceed 72 hours if pathological waste is unrefrigerated
Thailand (Chiang Rai)	- Separate into two types: (i) sharp items; (ii) non sharp items (COVID-19 waste under the non-sharp items) - Disinfect and double bags - Designate a specific storage area - Send waste from community healthcare facilities to district healthcare facilities once a week - Temperature-controlled storage available at district level - Transport by licensed WMSPs (require temperature-controlled vehicle) - Treat within 48 hours after being transported - Disinfect vehicles and bins daily with NaClO

Source: Compiled by authors based on country survey, 2020

Table 16. WHO recommended segregation and collection scheme.

Waste categories	Colour of container and markings	Type of container	Collection frequency
Infectious waste	Yellow with biohazard symbol (highly infectious waste should be additionally marked HIGHLY INFECTIOUS)	Leak-proof strong plastic bag placed in a container (bags for highly infectious waste should be capable of being autoclaved)	When three-quarters filled or at least once a day
Sharp waste	Yellow, marked SHARPS with biohazard symbol	Puncture-proof container	When filled to the line of three-quarters
Pathological waste	Yellow with biohazard symbol	Leak-proof strong plastic bag placed in a container	When three-quarters filled or at least once a day
Chemical and pharmaceutical waste	Brown labelled with appropriate hazard symbol	Plastic or rigid container	On demand
Radioactive waste	Labelled with radiation symbol	Lead box	On demand
General health-care waste	Black	Plastic bag inside a container which is disinfected after use	When three-quarters filled or at least once a day

Source: WHO, 2017

Transportation to offsite treatment

Offsite transport includes activities related to carrying of healthcare waste on public roads from the respective healthcare facilities to the treatment facilities. It is important to offer regular and increased waste collection services for identified COVID-19 healthcare facilities. When possible, use specialized, licensed healthcare waste service providers for transporting healthcare waste. If hazardous wastes are shipped across an international frontier for treatment, they should comply with national regulations and with international agreements (Secretariat of the Basel Convention, 1992). Where there are no national regulations, responsible authorities may refer to recommendations on the transport of dangerous goods published by the United Nations (UN, 2013) and others (WHO

Regional Office for Europe, 2013). Some countries have introduced a manifest system or waste-tracking note before sending hazardous healthcare waste offsite, which includes the following information: (i) waste type, (ii) waste sources, (iii) pick-up date, (iv) destination, (v) driver's name, (vi) number of containers or volume, (vii) receipt of load received from responsible person at the pick-up area.

Most of the countries which have responded to the questionnaire survey have taken specific actions on healthcare waste management from the healthcare facilities, as discussed above, meanwhile, regulations, operations and recommendations for segregation, storage, and transportation of COVID-19 waste generated from households and quarantine locations are also applied, as shown in Table 17.

Table 17. Existing practices of storage and transport of healthcare waste in selected countries.

Country (City)	COVID-19 waste generated from a household or a quarantine location
Afghanistan	Carried out no waste separation at source
Kenya	- Treated as potentially infectious, and disinfect - Sealed the bag when its 2/3 full, with appropriate adhesive tape - Segregated and stored in leak-proof liner bags/container labelled "infectious waste"
Mexico	- Designated the temporary storage for waste biological-infectious hazardous - Stored packaged biological-infectious hazardous in metal or plastic containers with a lid and a label - Defined the temporary storage period according to the HCW types
South Africa	- Treated the waste such as disposable cloths, tissues, gloves, masks, etc. generated from possible cases - Cleaned HCW areas - Placed red liners in a second red liner and tied - Placed in a suitable and secure place and marked for storage until the individual's test results are known - Placed in the suspect or patient's room awaiting collection - Avoided from placing HCW in communal waste areas - Stored the bags separately for five (5) days in the sun before they are put out for collection by the municipality
India	- Treated biomedical waste generated from quarantine camps/quarantine-home/home-care as domestic hazardous waste defined under Solid Waste Management Rules, 2016, and be disposed as per provisions under Biomedical Waste Management Rules, 2016 and the guidelines - Use dedicated carts / trolleys / vehicles for transport of biomedical waste - Ensure sanitization of vehicles with 1% sodium hypochlorite after each trip
Sri Lanka	(See "Annex: Case studies, Sri Lanka")

Source: Compiled by authors based on country survey, 2020

Thus, healthcare waste generated by households such as potentially contaminated masks, gloves and used or expired medicine should ideally be treated as infectious waste, disposed of separately, and collected by municipal specialists or private sector waste management operators. Additional considerations include:

Mapping sources of waste generation in order to identify changes in waste amounts and flows and increase resource use efficiency

- Map out sources generating potentially COVID-19-contaminated waste and healthcare waste, including hospitals, home care centers, testing labs, quarantine camps and homes with self-isolated patients (if legally permitted).
- Map out sources where waste generation has decreased due to preventive closures, which may include schools, commercial complexes, and public places.
- Identify places where illegal dumping is taking place.

Separate contaminated waste from households

- Ideally, all potentially infectious waste should be put in a sealed bag and double bagged if possible. It needs to be handled as residual waste not meant for material recovery.
- If it is not possible to separate contaminated waste from other waste in the household, then all waste from that household should be placed in a double-layer bag and sealed.
- If needed, local governments may consider distributing waste bags to households and communities.

Minimization and recycling

- Conduct waste minimization.
- Ensure continuity of recycling, so that the household keeps on segregating recyclables and non-recyclables. In general, there are three types of waste separation recommended: (i) Mixed waste (including special waste⁴, as seen in Sri Lanka, for example); (ii) Recyclables; (iii) Organic waste.

Packaging and storage

- Mixed waste and recyclables should be kept prior to collection.
- Mixed waste and special waste that contains potentially infectious materials should be double bagged.
- Some municipalities or private collection services provide special colored bags with certain thickness requirements specifically for collection of waste containing potentially contaminated materials.

Municipal waste collection and transport

- Human and financial resources and assets for waste collection can be reassigned based on mapping of changing waste sources and flows (above).
- The frequency and coverage of waste collection can be increased in communities with common collection points and high population density, especially informal settlements.
- Informal sector collectors should be fully engaged in addressing the crisis.
- Possibilities for ad-hoc services, including by third party operators, for collection of waste from COVID-19 households in specific containers can be considered.
- The frequency of recyclables collection can be adjusted..

⁴ "Special waste" includes waste and potentially contaminated items such as face masks, masks, gloves, handkerchiefs, tissues, sanitary pads, diapers, and other materials contaminated by body fluids of residents.



3.2. Treatment and disposal methods of healthcare waste

Healthcare waste, particularly COVID-19 waste, needs to be treated following local guidelines and regulations, mostly including thermal treatment (Damanhuri, 2020; Manomaivibool, 2020; Modak, 2020; Oelofse, 2020;

Pariatamby, 2020; Wainaina, 2020). Some of the common technologies for treatment and destruction of healthcare waste and sustainable assessment of technology for choosing among them are discussed below, with their pros and cons.

Incinerator:

Incineration is a high-temperature, dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a significant reduction of waste volume and weight. High-heat thermal processes take place at temperatures from about 200 °C to more than 1000 °C. They involve the chemical and physical breakdown of organic material through the processes of

combustion, pyrolysis or gasification. However, to control the environmental pollutions, the Stockholm Convention has suggested to apply the Best Available Technology (BAT) with a combination of adequate primary and secondary measures to control dioxin and furan air emissions no higher than 0.1 ng I-TEQ/Nm³ (at 11% O₂) and less than 0.1ng I-TEQ/l for wastewaters discharged from the facility (UNEP, 2007).

Table 18 - Pros and cons in applying the incineration option



Pros:

- Significant reduction of waste volume and weight
- Ensure decontamination (combustion at minimum 800-degree Celsius temperature)
- No post treatment needed for final disposal



Cons:

- High energy requirement
- The combustion of health-care waste produces mainly gaseous emissions, including steam, carbon dioxide
- Produce toxic substances such as nitrogen oxides and volatile substances (e.g. metals, halogenic acids) under incomplete combustion
- Potential emissions of carcinogens
- Particulate matter, plus solid residues in the form of ashes, which are to be treated as toxic

Source: Compiled by authors based on WHO, 2014 and UNEP-IETC, 2012



Autoclave:

Autoclaves have been used for more than a century to sterilize medical instruments, and for several years they have been adapted for the treatment of infectious waste. An autoclave consists of a metal vessel designed to withstand

high pressures, with a sealed door and an arrangement of pipes and valves through which steam is introduced into and removed from the vessel.

Table 19 - Pros and cons in applying the autoclave option.



Pros:

- Suitable for soiled wastes, bedding and personal, protective equipment, clinical laboratory waste, reusable instruments, waste sharps, and glassware
- Low-heat thermal processes produce significantly less air pollution emissions than high-heat thermal processes
- No specific pollutant emissions limits for autoclaves and other steam treatment systems
- Waste does not require further processing, it can be disposed on a municipal landfill as it is disinfected and not hazardous anymore. However, some countries request to render the waste unrecognizable then it is shredded afterwards, but this depends on the legal regulation.
- Available in various sizes from lab autoclaves to large autoclaves used in large waste treatment facilities



Cons:

- Cannot treat volatile and semi volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical and radiological waste, large and bulky bedding material, large animal carcasses, sealed heat-resistant containers
- Odors can be a problem around autoclaves if there is insufficient ventilation
- Poorly segregated waste may emit low levels of alcohols, phenols, formaldehyde, and other organic compounds into the air
- Treated waste from an autoclave retains its physical appearance
- Waste requires further processing for final disposal

Source: Compiled by authors based on WHO, 2014 and UNEP-IETC, 2012



Microwave treatment:

Microwave technology is essentially a steam-based process where treatment occurs through the action of moist heat and steam generated by microwave energy.

Water contained in the waste is rapidly heated by microwave energy at a frequency of about 2,450 MHz and a wavelength of 12.24 cm.

Table 20 - Pros and cons in applying the microwave option.



Pros:

- Suitable for soiled wastes, bedding and personal, protective equipment, clinical laboratory waste, reusable instruments, waste sharps, and glassware
- A fully enclosed microwave unit can be installed in an open area, and used with a HEPA filter to prevent the release of aerosols during the feed process.
- Odour is somewhat reduced, except in the immediate vicinity of the microwave unit
- A large-scale, semicontinuous microwave unit is capable of treating about 250 kg/hour (3,000 tonnes per year)
- Waste does not requires further processing, it can be disposed on a municipal landfill as it is disinfected and not hazardous anymore. However, some countries request to render the waste unrecognizable then it is shredded afterwards, but this depends on the legal regulation.
- Aavailable in various sizes from lab microwave units to large microwave units used in large waste treatment facilities



Cons:

- Volatile and semi volatile organic compounds, chemotherapeutic waste, mercury, other hazardous chemical waste and radiological waste should not be treated in a microwave
- Treated waste from a microwave unit retains its physical appearance
- Waste requires further processing for final disposal
- Very limited volume reduction, no weight reduction

Source: Compiled by authors based on WHO, 2014 and UNEP-IETC, 2012

Disposal

Residual waste remaining after any of the above treatment options is mostly disposed of on land. This should be in a controlled or sanitary landfill, if available. Table 21 summarizes questionnaire survey results on how country stakeholders currently treat and dispose of their healthcare waste, including COVID-19 waste generated from healthcare facilities, households and quarantine locations. According

to the country-based information, it can be argued that most countries have made some efforts to introduce applicable technologies to treat the healthcare waste generated from the healthcare facilities. However, there is a huge issue in managing healthcare waste generated within the households. Most of these wastes are disposed of in open dumpsites along with other municipal solid wastes.

Table 21 - COVID-19 waste treatment and disposal in countries.

Country (City)	COVID-19 waste generated from a healthcare facility	COVID-19 waste generated from household/quarantine location
Bangladesh	Incinerator	N/A
India	- Common biomedical waste treatment facility (CBWTF) (See Table 22 below) - Permit disposal by deep burial only in rural or remote areas without CBWTF facilities - In case of generation of large volume of yellow color coded (incinerable) COVID-19 waste beyond the capacity of existing CBWTFs and the captive BMW incinerators; permit HW incinerators at existing the treatment, storage, and disposal facilities (TSDFs) or captive industrial incinerators if any exist in the State/Union territory. In such case, ensure separate arrangement for handling and waste feeding.	- Hand over to waste collector identified by urban localities or as per the prevailing local method of disposing general solid waste - Urban local body (ULB) shall engage CBWTF operator for ultimate disposal of biomedical waste collected from quarantine home/home care or waste deposition centers or from doorsteps as may be required depending on local situation; ULB shall make agreement with CBWTF in this regard.
Indonesia (some local governments)	- Mostly incineration, disinfect at source and transport to the disposal sites or open burning (if no incinerator), hazardous waste landfill (See "Annex: Case studies, Indonesia")	- Directly burn every day at home - Collect and transport by official staff to the cement factory incinerator for burning process (Padang) (See "Annex: Case studies, Indonesia")
Japan	Incineration, melting, steam sterilization (autoclave) followed by shredding, dry sterilization followed by shredding, disinfection followed by shredding and disposed the specific sanitary landfill	- Mix recyclable items with other combustible waste (and incinerate), - Discharge incombustible waste after 7-day storage at source
Kenya	- Incineration, microwave, crude dumping of ash and microwaved end-product at the municipal dumpsite (See "Annex: Case studies, Kenya")	N/A
Malaysia	Mostly incineration	Transport all ash from the incineration plants to the hazardous waste treatment center and solidify with cement to be disposed in a special landfill
Mexico	Treat and dispose of as normal hazardous healthcare waste (autoclave, incinerator, microwave, etc.)	Incinerated or confined in an emergency cell in a landfill and earth covered everyday.
Nepal	Mostly burned, small-scale incineration, or dumped backyard, municipal landfill, or other areas	N/A
Saint Lucia	Steam sterilization, autoclave, chemical disinfection (some)	N/A
South Africa	Incineration, non-burn technologies (autoclaves, converter, microwave)	- COVID-19 waste generated in a household is managed as part of municipal waste - Waste generated at a quarantine facility is treated as healthcare waste and must be treated at an incineration or non-burn treatment facility
Sri Lanka	Incinerator	(See "Annex: Case studies, Sri Lanka")
Thailand (Chiang Rai)	Incinerator, autoclave, waste management service provider (WMSP), sanitary landfill	N/A

Source: Compiled by authors based on country survey, 2020

Among different treatment technologies, incineration is a widely used treatment method, either by cities or private operators. The questionnaire survey provided estimates for the number of incinerators currently installed and operating in selected countries, and this is summarized in Table 22.



Table 22 - Number of incinerators for HCWM in countries.

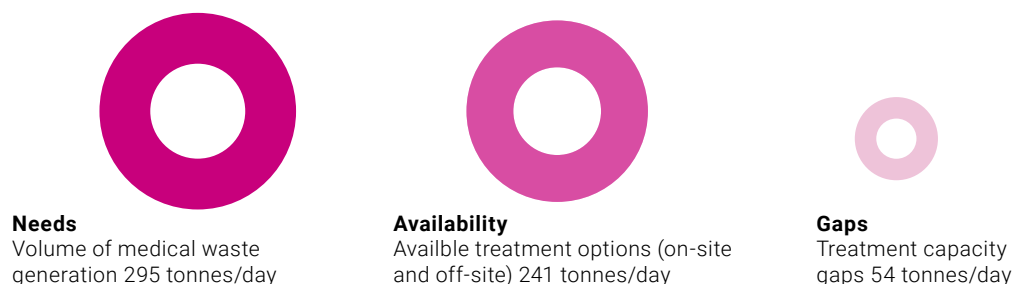
Country	Number of incinerators
Bangladesh	5 incinerators are installed, of which 3 are operating
India	225 incinerators installed
Indonesia	Out of 646 hospitals dedicated to handle COVID-19 patients, 20 have their own licensed incinerators. In general, there are 110 licensed incinerators in regular hospitals located mainly in urban areas. There are 9 incinerators, mostly damaged, with only one licensed in Bangka Belitung province, and 2 incinerators with no license from Ministry of Environment and Forestry, in Pangkal Pinang (the capital of Bangka Belitung province).
Kenya	10 diesel operating incinerators located in high volume health care facilities
Malaysia	12 incinerators for hazardous waste
Mexico	19 incinerators installed with capacity enough to handle 117,519 tons/year
Saint Lucia	20 small scale pyrolysis units purchased, but not installed and commissioned
South Africa	9 incinerators
Thailand	15 incinerators for infectious waste in the country 62 hospitals operate their own incinerators 1 incinerator at Mae Fah Luang University in Chiang Rai

Source: Compiled by the authors based on the country survey, 2020

The following key issues were identified from the questionnaire survey results:

- **There is limited availability and accessibility of treatment and disposal options for healthcare waste management in developing countries.** This caused difficulty in handling healthcare waste generated during the COVID-19. For example, operational capacity of existing healthcare waste treatment-disposal during normal pre-COVID-19 conditions in Indonesia, including both on-site and off-site facilities, is lower than the amount of healthcare waste generated (Damanhuri, 2020).

Figure 8 - Capacity assessment of healthcare waste treatment facilities in Indonesia



Source: Danmahuri, 2020



- **The distribution of healthcare waste treatment and disposal facilities is also not evenly distributed within the countries.** Most treatment facilities are generally located in the urban regions, while peri-urban and rural areas suffer due to lack of treatment options. For example, Table 23 presents the distribution of healthcare waste treatment facilities in Indonesia. The data shows that most of the treatment facilities are located in the Java region (85%). The eastern part of the country particularly lacks access to healthcare waste treatment options (Damanhuri, 2020). The situation is similar in India, where some states such as Arunachal Pradesh, Andaman and Nicobar, Goa, Lakshadweep, Mizoram and Nagaland and Sikkim do not have Common Bio-medical Waste Treatment and Disposal Facilities for the treatment and disposal of biomedical waste⁵.

Table 23 - Disparity of HCW treatment capacity

Region	Western Indonesia		Central Indonesia			Eastern Indonesia	Total (ton/day)
	Sumatra	Java	Bali-Nusa Tenggara	Kalimantan	Sulawesi	Maluku-Papua	
On-site facilities	8.58	41.72	2.40	8.00	9.51	0	70.21
Off-site facilities (private sector)	5.40	225.48	0	10.80	2.40	0	244.08
Total	13.58	267.20	2.40	18.80	11.91	0	314.29

Source: Sinta Saptarina Soemiarno, Webinar, 28 April 2020, <https://youtu.be/ULfmAnbcxGc>

- **Another common issue is that the available treatment and disposal options are often not well-designed, well-built or well-managed due to lack of knowledge, capacities and financial difficulties.** According to Stockholm Convention guidance, if healthcare waste is incinerated in conditions that do not constitute best available techniques or best environmental practices, there is potential for the release of PCDD [polychlorinated dibenzodioxins] and PCDF [polychlorinated dibenzofurans] in relatively high

concentrations (Secretariat of the Stockholm Convention, 2006). The guidance also includes the study result (Batterman, 2004) which shows most small-scale health-care incinerators in developing countries have significant problems regarding siting, operation, maintenance, and management of these incinerators. As a result of these concerns, together with the very high costs for modern incineration to meet the best available technique (BAT) standards, the WHO recommended interim treatment and disposal systems, as below (WHO, 2017):

⁵ According to the Bio-medical Waste Management Rules, 2016 in India, "bio-medical waste treatment and disposal facility" means any facility wherein treatment, disposal of bio-medical waste or processes incidental to such treatment and disposal is carried out, and includes common bio-medical waste treatment facilities.

- » Small healthcare waste incinerators, such as single-chamber, and drum and brick incinerators, are designed to meet the need for public health protection where there are no resources to implement and maintain more sophisticated technologies. This involves a compromise between the environmental impacts and other longer term or unintended negative health impacts from uncontrolled combustion with an overriding need for immediate public health protection if the only other alternative is uncontrolled dumping.
- » These circumstances exist in many developing countries, and small-scale incineration can be a transitional response to an immediate requirement (WHO, 2014). As far as possible, the burning of PVC plastics and other chlorinated waste should be avoided to prevent the generation of dioxins and furans.
- » Burning of healthcare waste in a pit is less desirable, but if it is genuinely the only realistic option in an emergency, or if chosen as an interim solution in case no other solution is in place, it should be undertaken in a confined area. The waste should be burned within a dugout pit, followed by covering with a layer of soil (WHO, 2014).
- » Temporary disposal through on-site burial is sometimes allowed due to unavailability of, or difficult access to, a sanitary landfill, although national and local municipal authorities need to upgrade the existing landfill or construct a sanitary landfill, if necessary, for the safe disposal of waste in the area. For the duration of the pandemic, infectious waste should be put in separated cells (e.g. separated pit, specifically designated disposal area, etc.) covered with locally available material, and with restricted access. (See video guidance from ISWA: "How to Dispose of Healthcare waste in Landfills", <https://youtu.be/y1FAb6l9vn4>).



Figure 9 - The use of PPE in Indonesia



Source: Lia G. Partakusuma (Webinar on 28 April 2020)

3.3. Occupational safety and health

Healthcare waste handlers are at the greatest risk during the COVID-19 pandemic. Workers are at risk from infection and injury from hazards, especially sharps that are not disposed of into puncture-resistant containers. The risk of acquiring a secondary infection following needle-stick injury from a contaminated sharp depends on the amount of the contamination and nature of the infection from the source patient. Thus, most countries have introduced strict guidance on Occupational Safety and Health (OSH) practices, based on the national and international standards. The following points are some information extracted from the desk study, as well as the questionnaire survey results.

- Provide necessary personal protective equipment for healthcare waste management workers, and inform and train them to use it for personal protection, such as masks (3-layer masks, N95 masks, surgical masks), gloves (heavy-duty gloves), rubber boots, disposable workwear/hazmat suit, goggles, faces-shields, and hair-cover/caps etc.
- Inform and train healthcare workers on good hygiene practices and safety measures, such as having hand sanitizer/cleaning agents in collection vehicles, hand washing/cleaning before and after picking-up waste, and disinfection (waste container/waste bags and waste collection vehicle).

3.4. Capacity building and awareness raising

During the COVID-19 epidemic/pandemic, the most important point of view is "continuity", to manage waste generated from healthcare facilities, households and quarantine locations with consideration of mitigating risks of COVID-19 transmission in any occasions of waste management flow, even if the amount of waste is drastically increased. As the Japanese government notified local governments, COVID-19 waste can be approached with in a manner similar to a disaster response (UNEP webinar on 25 June 2020: <https://www.unenvironment.org/events/conference/online-dialogue-integrated-waste-management-during-covid-19>). In this context, capacity building and awareness raising for COVID-19 waste management in emergency response, including contingency plan development as well as preparedness and build back better (BBB) for further improvement of healthcare waste management and MSW management, must be strengthened for all stakeholders, such as national and local governments, healthcare/ laboratory facilities, the private sector, the informal sector, and communities. The following training and capacity building actions can be taken:

- **Introduce training and education programmes** for workers of healthcare facilities on potential hazards from waste, the purpose of immunization, safe waste handling procedures, reporting of exposures and injuries, use of PPE, and hygiene practice
- **Training and education for logistics staff can be focused on the knowledge of risks and handling of hazardous waste**, including relevant legal regulations, waste classifications and risks, safe handling of hazardous waste, labelling and documentation, and emergency and spillage procedures.
- **Training and education also needs to focus on the drivers and waste handlers who are transporting healthcare waste** to the central treatment and disposal sites, informing them of the risks and handling of driving trucks with dangerous waste; in addition, verification indicating the confidence to transport hazardous waste is preferred.
- **In the time of the COVID-19 pandemic**, in addition to trainings on safe healthcare waste management, awareness raising on safe and healthy working environment for healthcare waste workers, including both for the formal and informal sectors, is required. For example:

- » Precautionary practices are required, such as
 - (i) Sick employees should stay home, practicing proper sneezing and coughing etiquette, and proper hand hygiene;
 - (ii) Routine environmental cleaning of workplaces;
 - (iii) Healthy employees notifying supervisors if a family member is sick;
 - (iv) Employers notifying other employee if an employee is confirmed to have COVID-19, for possible exposure.
 - » All workers must be trained on risks of exposure to the virus, hazards associated with that exposure, and appropriate workplace protocols to prevent or reduce the likelihood of exposure and infection.
 - » Strategies to reduce human interaction and ensure distance between workers at work should be put in place and work shifts could be revised.
 - » Consideration must be made to support livelihood loss of informal waste workers by coordinating with local waste pickers associations, to liaise on the purchase of personal protective equipment (PPE: gowns, gloves, masks), hygiene kits and food stocks.
- **Awareness raising and communications for healthcare staff and the public is also required.**
 - » Development of additional guidelines on handling, treatment, and disposal of waste generated during treatment/diagnosis/quarantine of a COVID-19 patient (public communications)
 - » Development of media (such as website, public service announcement) for hygiene practice and safe handling of waste management
- **Engage with all stakeholders in the society**
 - » Waste management must be declared an essential service.
 - » Engage and consult with stakeholders in the waste stream, both formal and informal, to identify roles and responsibilities in the coordinated work to ensure safe waste collection, treatment and disposal.
 - » Coordinate with informal workers to maintain and expand collection services in low income areas and take advantage of time to strengthen informal sector network.
 - » Staff shortage has to be accounted for and collection and treatment partners need to be included in assigning responsibilities.
- » The new collection schedule and other related changes in MSWM system must be communicated through radio, newspapers, and other accepted media.
 - » Citizens should dispose of waste as per provided guidelines by the municipality.
 - » Disposal must be in designated places only, to avoid formation of uncontrolled dumpsites and to enable the emergency teams to effectively maintain hygiene in the city.
 - » Restrictions and awareness raising, as well as distribution of PPE to waste pickers working in the disposal site should be considered.
 - » Relevant stakeholders should be consulted on strategies and guidelines for safe waste collection and treatment, to increase coordination, quality of services and improve the response plan.

Figure 10 - Awareness materials in Indonesia and Japan.



Source: Ministry of Environment and Forestry, Indonesia, 2020 and MOEJ, 2020

نفايات طبية / مواد خطرة
BIOHAZARDOUS / MEDICAL WASTE



BIOHAZARD

4 Conclusion and lessons learnt

In this concluding section, key lessons learnt are summarized under six thematic areas of (i) Policy, regulatory and institutional framework, (ii) safe handling of infectious waste, (iii) appropriate treatment and disposal methods, (iv) capacity development and awareness raising, and (v) data management, statistics, and learning, and (vi) general principles and guidance for managing infectious waste during the COVID-19 pandemic. Both policy makers and practitioners are required to consider these priority areas for establishing a sustainable healthcare waste management system during and after the COVID-19 at both national and local levels.

4.1. Policy, Regulatory and Institutional Framework

- International regulations and guidelines for safe HCWM are available and have been widely referred to and followed by most countries. This provides a good basis for management of healthcare waste during the COVID-19 pandemic, particularly for waste generated from healthcare facilities (whether existing or additional emergency healthcare facilities recently built).
- Additional regulations and guidelines are needed for healthcare waste generated from non-healthcare facilities, such as households and public places, especially due to increasing generation of potentially contaminated wastes (such as masks, tissues, disposable clothes, etc.).
- A robust institutional arrangement is needed during an emergency time such as the COVID-19 pandemic. Clear roles and responsibilities must be assigned for the collection of emerging COVID-19 waste from not only healthcare facilities, but also households and public places.
- COVID-19 waste management in emergency response, including contingency plan development as well as preparedness and build back better (BBB) for further improvement HCWM and MSWM, must be strengthened through review and enforcement of existing policy and regulatory frameworks. Conducting of a rapid assessment of the current system to identify the available capacities and gaps in the respective country or city and try to increase the usage of available treatment techs towards maximum capacity is important.

4.2. Safe handling of infectious waste

While it is important to anticipate the emergence of “special waste” generated during the COVID-19 pandemic, scientific insights⁶ such as the viability of the virus on different materials (up to 72 hours on plastics, 48 hours on stainless steel, 24 hours on cardboard, and 4 hours on copper) should be paid attention to for adjustment of existing waste management, and thus proper handling of waste can be performed as follows:

- Proper segregation, packaging, and storage of potentially contaminated materials (double bag)
- Adjustment of collection frequency based on priority (organic waste, infectious waste, etc.) and possible reduction of collection of recyclables
- Proper use of personal protective equipment (PPE) when handling healthcare waste, and hand hygiene as well as other precautionary practices to ensure health and safety of waste workers
- Encourage all waste workers including formal municipality employees to comply using PPE
- In addition, specific attention should be paid in particular to the informal sector (which plays an important role in waste management in normal times) from the viewpoint of sustainability, such as continuity of waste management by mitigating risks of infection transmission, social safeguards, OSH, and insurance, etc.

⁶ Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1, Apr. 2020 NEJM (<https://www.nejm.org/doi/full/10.1056/NEJMc2004973>)

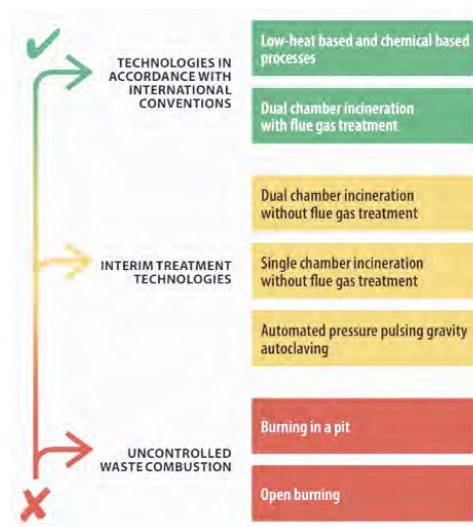
4.3. Appropriate treatment and disposal methods

The appropriate selection of treatment options is contextual and need to consider many aspects, not limited to national and international regulations, environmental and occupational safety, waste profile (characteristics and quantity), technology capabilities and requirements, costs, operation and maintenance requirements. Figure 11 shows some relevant technologies that can be applied for healthcare waste treatment (WHO, 2019). Most preferable options are the technologies that in accordance with the international conventions such as the Basel Convention and the Stockholm Convention. (UNEP, 2007). While non-incineration waste treatment options are recommended to apply wherever possible, WHO calls on all stakeholders to uphold the Stockholm Convention and work towards incrementally improving safe health care waste management practices to protect health and reduce harm to the environment (WHO, 2007).

In reality, there are many municipalities or healthcare facilities in developing countries which lack most preferable technologies to treat healthcare waste before disposal, and while the use of a landfill is a realistic option to protect public health, the landfill is usually an open dumpsite with open burning, and no operation and management with informal sector involvement. In this condition, it is recommended at least apply transitional or interim treatment methods such as single chamber incineration without flue gas treatment and a gravity-type autoclave. While such technologies are not considered as appropriate technologies under the international conventions due to not fulfil their requirements, can recommend as an interim solution. In emergency situation like COVID-19 pandemic, developing countries with limited resources and considering emergency situation can apply these interim treatment options in accordance with the WHO Guidelines as follows:

- **No use of open dumpsites for HCW (Chapter-8, WHO Guideline)**
 - » HCW should not be deposited on or around uncontrolled dumps. The risk to people such as waste pickers and animals coming into contact with infectious pathogens or hazardous materials is obvious, with further risks of subsequent disease transmission through direct contact, wounds, inhalation or ingestion, as well as indirectly through the food chain or a pathogenic host species.
- **Minimum approach to treatment and disposal (Chapter-8, WHO Guideline)**
 - » At a minimum, this entails segregation and other practices to minimize the amount of waste that needs to be treated.
 - » A treatment process that achieves at least the minimum required disinfection level, and safe disposal. Except for sharps waste, treated waste can be disposed of with regular municipal solid waste.

Figure 11 - A ladder of healthcare waste treatment technologies



Source: WHO, 2019

- » In extreme circumstances where no treatment is possible, hazardous healthcare waste from small healthcare facilities could be buried within the premises of the facility where public access can be restricted and the burial site is well constructed.
- » A safe burial pit design should be used. Larger healthcare facilities should make arrangements with a local landfill to provide a special cell or pit, daily soil cover, and restricted access.
- **Use a site operated in a controlled manner that may already exist for MSWM (Chapter-8, WHO Guideline)** Where a municipal waste landfill is available, it is possible to deposit HCW safely in two ways:
 - » In a shallow hollow excavated in mature municipal waste (preferably over three months old) immediately in front of the base of the working face where waste is being tipped. When a load of HCW has been deposited, it would be covered during the same day by the advancing tipping face of fresh municipal waste (preferably creating a layer of municipal waste around 2 m thick). Waste picking in this part of the site must be prevented. The same method is often used for hazardous solid industrial wastes, where the specific intent is to prevent animals and scavengers from re-excavating the waste materials once they have been deposited.
 - » In a deeper (1–2 m) pit excavated in a covered area of mature municipal waste (i.e. waste at least three months old). The pit is then backfilled with the mature municipal waste removed previously, and an intermediate soil cover (approximately 30 cm) or topsoil cover (up to 1 m). Waste picking in this part of the site must be prevented

- **Safe burial on hospital premises (Chapter-8, WHO Guideline)**

» Minimal approaches to HCWM need to be used in remote healthcare facilities and underdeveloped areas. In addition, minimal practices may also be necessary in temporary refugee encampments and areas experiencing exceptional hardship. Consequently, the safe burial of waste on hospital premises may be the only viable option available at that time. Even in these difficult circumstances, the hospital management can establish the following basic principles:

- Access to the disposal site should be restricted to authorized personnel only.
- The burial site should be lined with a material of low permeability, such as clay, dung, and river silt, if available, to prevent pollution of shallow groundwater and nearby wells.
- New water wells should not be dug near the disposal pit.
- Only infectious health-care waste should be buried (if general hospital waste was also buried on the premises, available space would be quickly filled).
- Larger quantities (>1 kg) of chemical wastes should not be buried at one time; however, burying small quantities occasionally is less likely to create adverse pollution.

- The burial site should be managed as a landfill, with each layer of waste covered by a layer of soil to prevent odors and contact with the decomposing waste, and to deter rodents and insects.

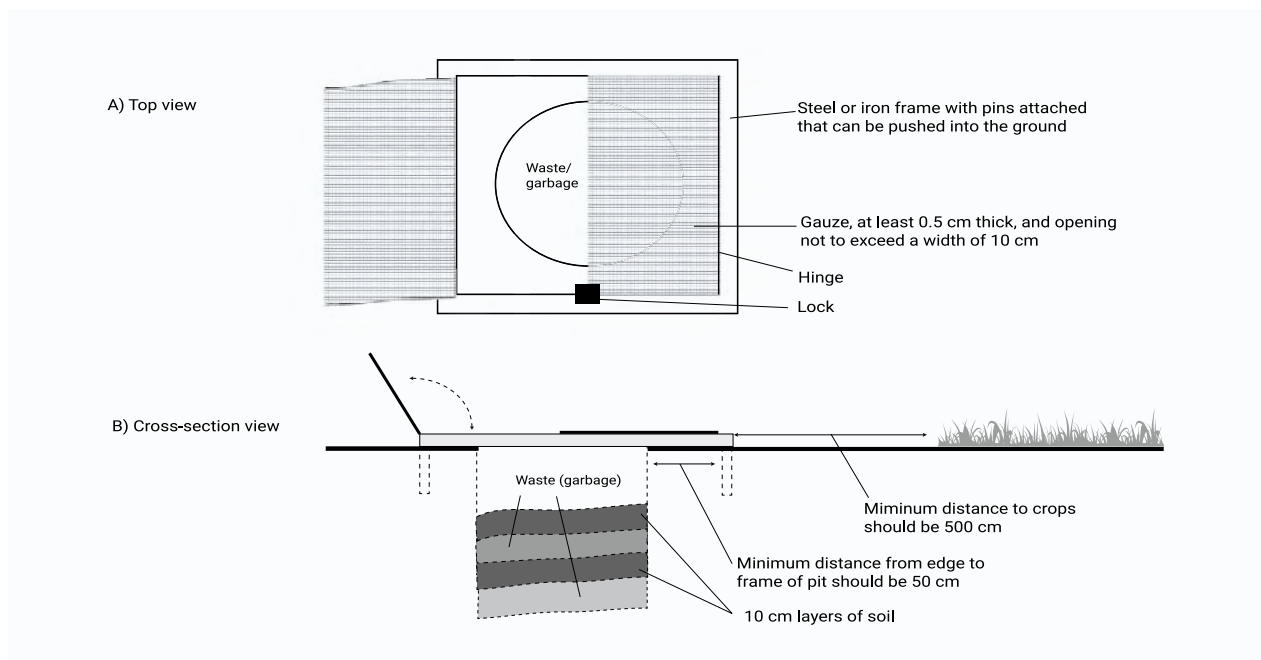
- The design and use of a burial pit is illustrated below.

- Once the pit is constructed, the safe burial of waste in minimal circumstances depends critically on staff following sensible operational practices. This must be insisted upon, and the local health-care manager must realize their responsibility for making an organized waste-disposal system work properly.

- **As an emergency response for treatment and disposal, WHO also introduced the following options (Chapter-14, WHO Guideline).**

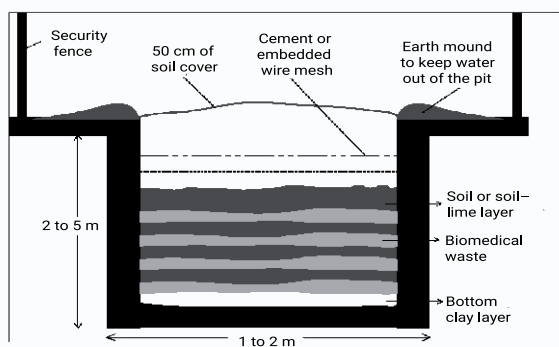
» **Onsite burial in pits** "Dig a pit 1–2 m wide and 2–3 m deep. The bottom of the pit should be at least 2 m above the groundwater. Line the bottom of the pit with clay or low permeable material. Construct an earth mound around the mouth of the pit to prevent water from entering. Construct a fence around the area to prevent unauthorized entry. Inside the pit, place alternating layers of waste, covered with 10 cm of soil (if it is not possible to layer with soil, alternate the waste layers with lime). When the pit is within about 50 cm of the ground surface, cover the waste with soil and permanently seal it with cement and embedded wire mesh."

Figure 12 - Burial option on hospital premises



Source: COSsen Zuid-Holland (2006)

Figure 13 - On site burial in pits



Source: WHO

- » **Burial in special cells in dumping sites (if available in the affected area)** "Cells to contain waste can be used when burying waste in dumping sites. The cell should be at least 10 m long and 3 m wide, and 1–2 m deep. The bottom of the cell should be at least 2 m above the groundwater. The bottom of the cell should be covered by soil or a material with low permeability. The waste in the cell should be covered immediately with 10-cm layers of soil to prevent access by people or animals (in diseases outbreaks, preferably spread lime on waste before covering with the soil). It is strongly recommended that HCW be transported in a safe manner to minimize public exposure to bio-contaminated wastes."

Figure 14 - Burial in special cells in dumping



Source: WHO

- » **Low-cost double-chamber incinerators** "Double-chamber incinerators may reach a temperature of about 800 °C with a residence time of more than one second in the second chamber to kill pathogens and break down some of the particulates in the outlet gases. The incinerators should be built at a convenient distance away from buildings. Such incinerators need to be heated with paper, wood or dry non-toxic waste (small quantities of kerosene may be added, if available) before adding infectious wastes."

- **Cement kiln (Basel Convention 27, ADB 26, China, Indonesia)** Some cement kilns and industrial furnaces may be used as temporary disposal facilities. The Chinese government has made use of cement kilns for this purpose, and the Indonesian government is considering this option to meet the gap of treatment capacity (See Annex: Case studies, Indonesia). The Basel Convention technical guideline 27 stipulates the following;

- » Co-processing in resource-intensive industries involves the use of waste in manufacturing processes for the purpose of energy and resource recovery, reducing the use of conventional fuels and raw materials through substitution. In particular, the co-processing of hazardous waste in cement kilns allows the recovery of the energy and mineral value from waste while cement is being produced.
- » Co-processing is a sustainable development concept based on the principles of industrial ecology focusing on the potential role of industry in reducing environmental burdens throughout the product life cycle (Mutz et al., 2007; Karstensen, 2009a). One of the most important goals of industrial ecology is to make one industry's waste another's raw material (OECD, 2000). Within the cement industry the use of wastes as fuel and raw materials is a positive, forward-thinking example.

Though "infectious healthcare waste" among hazardous wastes is categorized as not to be co-processed in cement kilns because of health and safety concerns, the guideline makes the following additional note.

- » Although lack of regulations (or their enforcement) governing healthcare waste management, particularly segregation at the source, will likely cause some facilities not to accept this type of waste based on health and safety concerns, process conditions in cement kilns would be appropriate to dispose of infectious wastes. In countries where occupational health and safety legislation so allows, such wastes may be co-processed in cement kilns.

Figure 15 - Photos of double-chamber incinerator



Source: WHO

- » **Open burning (WHO)** Burning of healthcare waste (infectious waste) is less desirable, but if it is genuinely the only realistic option in an emergency, it should be undertaken in a confined area (burning within a dugout pit), followed by covering with a layer of soil.
- » **Temporary storage (ADB)** As a temporary measure, secure facilities can be used as temporary storage in anticipation of additional emergency resources becoming available in the medium term.

4.4. Capacity development and awareness raising

- While healthcare facility workers are mostly trained in handling healthcare waste, additional capacity building and awareness raising is urgently needed for households, informal sectors including waste pickers, emergency healthcare facilities which employ volunteers and temporary workers.
- Capacity building for volunteers and user-friendly communication materials such as public service announcements on radio, and television/websites with frequent displays can be used to increase public awareness on safe handling of healthcare waste management.

4.5. Data management, statistics, and learning

- Data is an important part of planning and policy development, however this is often very difficult to obtain, particularly during a time of emergency where resources are allocated for urgent responses. Cooperating with academic institutions in order to gather data may be an option, and it better ensures that good and valid data is obtained.
- Regular discussion among stakeholders is a good practice and is needed to exchange views, data and information, as well as lessons learnt for continuous improvement of healthcare waste management, and it allows for immediate action to be taken at the time of an emergency.

4.6. General principles and guidance for managing infectious waste during the COVID-19 pandemic

The desk study and questionnaire responses captured how many countries and international development agencies have issued some general principles and specific guidelines to manage healthcare waste during the COVID-19 pandemic.

Table 24 - Findings on general principles and guidance for waste management during the COVID-19 pandemic



Healthcare Waste Management

- COVID-19 waste should be managed whenever possible using existing protocols for infectious and healthcare waste management, as stipulated in national and international guidelines and manuals
- Enhanced treatment and disposal capacities of medical waste in epidemic areas is urgently needed
- Identify gaps in capacity for medical waste treatment and disposal in different locations, such as urban versus rural areas, or large informal settlements
- Identify options for interim and emergency treatment and disposal, accounting for local constraints, and considering COVID-19 infection concerns in addition to broader environmental and human health impacts related to improper disposal of waste
- Ensure adequate supply of waste collection bins, bags and transportation trollies, PPEs, training and capacity building of the staff involved in COVID response.



Household Waste Management

- Continuity of management services should be prioritized
- Contingency planning should include securing necessary human resources and equipment as well as reducing risks for workers in local government, private companies, and the informal sector
- Special attention to MSWM related to COVID-19 is required to mitigate risks to people involved formally and informally in the MSWM operations and those benefiting from such services
- Make appropriate temporary changes in waste management operations
- Separately collect waste generated from households with COVID-19 positive occupants or suspected cases
- Adjust separation and recycling protocols as appropriate
- Strengthen awareness amongst waste management service providers
- Ensure adequate supply of waste collection bins, bags and transportation trollies, PPEs, training and capacity building of the staff involved in COVID response.

References

Supplementary material is available at:
<https://www.ccet.jp/publications>

1. Association of Cities and Regions for sustainable Resource management. (2020): *Municipal waste management and COVID 19: Summary of observed trends (March 2020)*. Association of Cities and Regions. https://www.acrplus.org/images/project/Covid-19/ACR_2020_03_Waste_management_covid19_graph.jpg
2. ADB (2020): Managing Infectious Medical Waste during the COVID-19 Pandemic. <https://www.adb.org/publications/managing-medical-waste-covid19>
3. CDC, TCEQ standards for waste disposal during COVID-19. (2020, April 1). The Colorado County Citizen. <https://www.coloradocountycitizen.com/article/news-columbus/cdc-tceq-standards-waste-disposal-during-covid-19>
4. Costley, S. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in South Africa* [Questionnaire].
5. Damanhuri, E. (2020). *Medical Waste Management for COVID-19: Current practices/responses in managing medical waste under the COVID 19 situation in Indonesia* [Questionnaire].
6. Fernandez, H. A (2020): ADB: Coronavirus could leave major Southeast Asian cities with 1,000 extra tonnes of medical waste per day. Eco-Business. <https://www.eco-business.com/news/adb-coronavirus-could-leave-major-southeast-asian-cities-with-1000-extra-tonnes-of-medical-waste-per-day/>
7. International Solid Waste Association. (2020). *Waste Management during the COVID 19 Pandemic: ISWA's Recommendations*. ISWA. <https://www.iswa.org/iswa/covid-19/>
8. Johns Hopkins (2020): COVID-19 Case Tracker, Coronavirus Resource Center. <https://coronavirus.jhu.edu/>
9. Manomaivibool, P. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in Thailand* [Questionnaire].
10. Ministry of Public Administration, Home Affairs, Provincial Councils & Local Government. (2020). *Interim Guideline for Management of Solid Waste Generated by Households and Places under Self-Quarantine due to COVID-19 Outbreak*.
11. Modak, P. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in India* [Questionnaire].
12. Nugraha, C. (2020, April 28). *Peran Perusahaan Pengelola Limbah Medis dalam Penanganan Wabah COVID 19* [Presentation]. Diskusi Pengelolaan Limbah B3 Medis COVID 19 di Indonesia, Webinar.
13. Oelofse, S., & Godfrey, L. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in South Africa* [Questionnaire].
14. Pariatamby, A. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in Malaysia* [Questionnaire].
15. Solid Waste Association of North America (SWANA). (2020). *Guidance on Coronavirus (COVID 19)*. Solid Waste Association of North America. https://swana.org/docs/default-source/advocacy-documents/guidance_on_coronavirus-2020_03_06.pdf?sfvrsn=fee6b88a_2
16. UNEP and Secretariat of the Basel Convention. (2003). *Technical Guidelines on the Environmentally Sound Management of Biomedical and Healthcare Waste (Y1; Y3)*. Secretariat of the Basel Convention. <http://bcr.tsinghua.edu.cn/en/atm/7/20200309115829124.pdf>
17. United Nations Industrial Development Organization (UNIDO). (2020). *Emergency Response Assistance to the Outbreak of Coronavirus Disease 2019 in China*. United Nations Industrial Development Organization.
18. Wainaina, A. (2020). *Medical Waste Management for COVID 19: Current practices/response in managing medical waste under the COVID 19 situation in Kenya* [Questionnaire].
19. World Health Organisation (WHO) (2020); WHO announces COVID-19 outbreak a pandemic. <https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/3/who-announces-covid-19-outbreak-a-pandemic>

20. World Health Organization (WHO). (2014). *Safe management of wastes from healthcare activities*. World Health Organization. https://www.who.int/water_sanitation_health/publications/safe-management-of-wastes-from-healthcare-activities/en/
21. World Health Organization (WHO). (2017). *Safe management of wastes from healthcare facilities: A summary*. <https://apps.who.int/iris/bitstream/handle/10665/259491/WHO-FWC-WSH-17.05-eng.pdf;jsessionid=91A3806F2AF2049CCD058A09A062C2EA?sequence=1>
22. World Health Organisation Regional Office for Europe (2013): Technical Guidelines – Transport of Infectious Clinical Waste (UN3291). <https://www.washinhcf.org/wp-content/uploads/2019/03/Guidelines-Transport-of-infectious-waste-UN3291.pdf>
23. World Health Organisation (WHO) (2019): Overview of technologies for treatment of infectious and sharp waste from health care facilities. <https://apps.who.int/iris/bitstream/handle/10665/328146/9789241516228-eng.pdf?ua=1>
24. World Health Organisation (WHO) (2007). WHO core principles for achieving safe and sustainable management of health care waste. World health Organization, Geneva. http://www.who.int/water_sanitation_health/medicalwaste/hcwprinciples.pdf
25. Letter S.167/MENLHK/PSLB3/PLB.3/3/2020 in Bahasa: https://drive.google.com/file/d/1nznk7XTIjVSb6iSCFD87hEMtPt_esAy6/view
26. Circular Letter # SE.2 / MENLHK / PSLB3 / PLB.3 / 3/2020 in Bahasa: https://drive.google.com/file/d/1GEUcbk9mERT-y97WTeRw4_gn7JY3GZx/view
27. Sinta Saptarina Soemiarno (Director for Performance Assessment for Waste Management, Ministry of Environment and Forestry: the Handling Infectious Waste - Covid-19)
28. Strategy Guidance: Solid Waste Management Response to COVID-19, UN-HABITAT, May 2020
29. Compendium of technologies for treatment / destruction of healthcare Waste, UNEP-IETC, 2012: http://wedocs.unep.org/bitstream/handle/20.500.11822/8628/IETC_Compendium_Technologies_Treatment_Destruction_Healthcare_Waste.pdf?sequence=3&isAllowed=y
30. Japanese awareness material for citizens: https://www.env.go.jp/saigai/novel_coronavirus_2020/flyer_on_disposal_of_contaminated_household_waste.pdf
31. National Infection Prevention and Control Guidelines for Health Care Services in Kenya, Ministry of Public Health and Sanitation, Ministry of Medical Services, Dec. 2010
32. Safe management and disposal of safety product in prevention of spread of COVID-19, Ministry of Health, Kenya, Apr. 2020
33. Interim Guideline for Management of Solid Waste Generated by Households and Places under Self-Quarantine due to COVID-19 Outbreak, Guideline (Interim), Sri Lanka, Ministry of Public Administration, Home Affairs, Provincial Councils & Local Government, Mar. 2020
34. Managing Infectious Medical Waste during the COVID-19 Pandemic, ADB, 2020: <https://www.adb.org/sites/default/files/publication/578771/managing-medical-waste-covid19.pdf>
35. Technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns <http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/techguid/cement/tg-cement-e.pdf>
36. UNEP (2020): COVID-19 Waste Management Factsheets. <http://wedocs.unep.org/bitstream/handle/20.500.11822/32779/FSSum.pdf?sequence=1&isAllowed=y>
37. UN (2013): UN recommendations on the transport of dangerous goods – Model Regulations, Eighteenth revised edition. www.unece.org/unece-and-the-sdgs/unece-and-the-sdgs.html
38. UNEP (2007). Guidelines on Best Available Techniques and provisional guidance on Best Environmental Practices relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutant: <http://chm.pops.int/Implementation/BATandBEP/BATBEPGuidelinesArticle5/tabid/187/Default.aspx>
39. Notification from Ministry of Environment, Forest and Climate Change, Government of India, New Delhi, 28th March 2016

Annex: Case studies

Indonesia

Policy and institutional arrangement for HCWM

According to Indonesian law, HCWM is a part of hazardous waste (HW) management and regulated by laws and regulations such as Environment Protection and Management related to the hazardous material, and the government regulation indicating the position of HCW as part of a hazardous management approach. The details of HCWM are stipulated in the Ministry of Environment and Forestry (MOEF) Regulation as "Procedures and technical requirements for the management of hazardous and toxic waste from health service facilities". It regulates how to reduce, sort, store, transport, treat, bury, and dispose of hazardous and toxic waste. It can be done either by the healthcare facility (on-site) with a permit from the MOEF, or by a private company for transportation and treatment/disposal (also with a permit from the MOEF). The technology that can be applied for on-site treatment is autoclave and incineration, while for off-site treatment, the private company can only use an incineration process.

COVID-19 waste management

In Indonesia, the coordination of COVID-19 issues is under the "COVID-19 Taskforce" (Taskforce) for the acceleration of handling COVID-19, under the National Disaster Control Agency. In March 2020, the MOEF enacted guidance concerning handling of COVID-19 waste generated from healthcare facilities, ODP (people under surveillance) and households, addressed to the chair of the Taskforce. The following operational guides both for COVID-19 waste, are introduced in the guidance.

COVID-19 waste generated from the healthcare facility

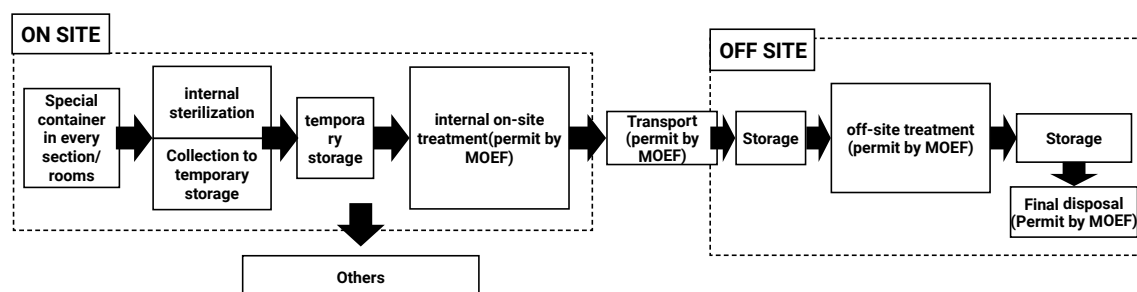
The below figure shows the HCWM flow at healthcare facilities in general, and COVID-19 waste is also managed by the same flow. The operation is split into two components which are on-site and off-site flows. For COVID-19 waste management aspects, specific precautions and additional operations are required in each category of the flow, both in on-site and off-site locations.

- Carry out storage of waste in sealed packages no later than 2 (two) days after it is produced
- Transport and/or shred in the treatment as HW
- Incinerate with the combustion temperature at least of 800 degree Celsius or autoclave equipped with a shredder
- Pack and label combustion residues or chopped autoclave as hazardous and toxic waste to be stored in the temporary storage site
- Transport to the manager of the hazardous and toxic waste for its further treatment

COVID-19 waste generated from ODP (people under surveillance) originating from households

- Collect it as infectious waste with proper PPE such as masks, gloves, and personal protective clothing
- Pack with use of a closed container
- Transport and/or shred in the treatment as HW
- Convey information to the public about infectious waste management as follows.

Figure - General flow of COVID-19 waste management



Source: Damanhuri (Webinar on 28 April 2020)



- Pack PPE waste such as masks, gloves, personal protective clothing separately with use of a closed container labeled as “infectious waste”
- Carry out collection from each source with officers from the responsible department in the field of environmental hygiene and health, to be transported to the designated collection location, before being handed over to the processing of hazardous and toxic waste.

COVID-19 waste generated from households

- Equip all cleaners or garbage carriers with PPE, especially masks, gloves and safety shoes which must be sterilized every day
- Encourage making efforts to reduce the generation of PPE waste by using reusable masks that can be washed every day
- Require tearing or cutting disposable masks and neatly pack before throwing them in the trash to avoid misuse
- Prepare a special trash bin/drop box in a public space by the local government

Challenges for COVID-19 waste management in Indonesia

One of the biggest challenges in Indonesia is that the operational capacity of existing HCW treatment and disposal, even during normal conditions, for both on-site and off-site facilities is lower than the amount of HCW currently generated. In addition, there is a capacity gap on HCWM according to the area of Indonesia. Rural and remote areas are facing a lack of treatment capacities on HCWM,

while the amount of infectious waste rapidly increased in the current COVID-19 pandemic situation (See “2.2. Volume of healthcare waste generation”). The following proposal to address those issues are raised by MOEF.

- Optimize treatment capacity both of on-site and off-site facilities
- Seek collaboration with the cement kiln industry
- Increase the role of local governments in HCWM
- Develop HCWM facilities in 2020-2024 in 32 locations, with an integrated monitoring system (5 units by 2020)
- Invite a private company to develop the centralized HCWM facilities in all regions
- Utilize alternative technologies (besides incineration technology)
- Scenarios to increase the treatment capacity include:
 - If the capacity of private companies is increased to its maximum capacity, the total capacity will increase by 2.8 times, though the facilities are still not distributed equally.
 - If the cement kiln industry can be used to treat COVID-19 waste, the total capacity will increase by 3.6 times; the distribution is relatively equal, but waste transportation will be another problem in certain areas.
- Another treatment/handling for burying and Landfilling (MOEF Regulation)
- Another option is to give special permits for the on-site incinerators that are already built, but do not fulfill the MOEF criteria, and allow them to accept the waste from other regions that are not listed in the permit.

Kenya

Policy and institutional arrangement for HCWM

HCWM in Kenya is regulated by the Environmental Management and Co-ordination (Waste management) Regulation formulated in 2006 (NEMA regulation). The National Policy on Injection Safety and Medical Waste Management in 2007, followed by National Infection Prevention and Control Guidelines for Healthcare services in Kenya in 2010 (referred to as "MOH guideline") were formulated for proper HCWM. Based on these documents, "Safety management and disposal of safety products in prevention of spread of COVID-19" was formulated in April 2020, due to the COVID-19 epidemic/pandemic situation.

Guide for HCW treatment

HCW treatment and disposal options are stipulated in the MOH guideline. COVID-19 waste generated from the healthcare facilities can be managed under the same procedures. The guideline specifically includes the following operations;

- Infectious waste should be incinerated in double-chamber incinerators followed by disposal of ashes from the incinerator in an ash pit. In densely populated areas, the incinerator should reach 1,200 degree Celsius if possible, and in other areas, the use of decentralized and low-cost incinerators can be applicable.
- Health centers and dispensaries may burn infectious waste in oil drum incinerators. Sanitary landfill or burial is an alternative solution when underground water is not at risk for contamination. But be careful to dispose of solid waste on land in a manner that can protect the environment.
- For example, spread the waste in thin layers, compact it to the smallest practical volume, and then cover it with soil at the end of each working day. Incineration is the preferred method for waste disposal, as the heat will generally be sufficient to destroy infectious microorganisms and will also prevent waste picking and reuse of discarded items. If incineration is not possible, then careful burial is the next best alternative.
- Simple incinerators can be built from locally available materials—bricks, concrete blocks, or used fuel or oil drums. In general, such an incinerator is useful only for small, usually rural, healthcare facilities that do not have large quantities of healthcare waste. If the healthcare facility is large, it is more efficient to build or install an incinerator large enough to accommodate all the facility's waste-disposal needs. A drum incineration operation requires the following procedures.
 - Choose a place that is downwind from the clinic to prevent smoke and odours from coming into the healthcare facility and the neighbouring communities
 - Make sure there are sufficient air inlets on the sides of the oil drum and bottom of the fire bed
 - Place the incinerator on hardened earth or on a concrete base

- Burn only healthcare waste, and treat the ash as general waste
- Use a regular community disposal site for general waste. (This will conserve both time and resources.)
- Healthcare I waste might not burn easily, especially if it is wet. Add kerosene to make the fire hot enough to burn all waste. Be sure to add the kerosene before starting the fire—adding kerosene after the fire has started might cause an explosion
- Bury or otherwise dispose of the ash in a designated area
- The following waste should not be incinerated.
 - » Pressurized gas containers (aerosol cans), Large amounts of reactive chemical waste, Silver salts and photographic or radiographic wastes, Plastic containing polyvinyl chloride (blood bags, IV sets, or disposable syringes), Waste containing high mercury or cadmium content, for example, broken thermometers, used batteries, and lead-lined wooden panels
- The following disposal methods are also highlighted in the guideline.
 - Only contaminated and hazardous waste needs to be buried.
 - The disposal site should be fenced and off limits to unauthorized persons.
 - The burial site should be lined with a material of low permeability, if possible.
 - Select a site at least 50 meters away from any water source to prevent contamination of the water table.
 - The site should have proper drainage, be located downhill from any wells, free of standing water, and not be in a flood-prone area. The site should not be located on land that will be used for agriculture or development.
 - The waste pit on the premises is also the option to dispose healthcare waste in a following manner.
 - » Find an appropriate location as described above

BOX: Small scale incineration

- Single-chamber, drum and brick incinerators do not meet the BAT requirements of the Stockholm Convention guidelines (Secretariat of the Stockholm Convention, 2006).
- In addition, WHO reported that small-scale incineration should be viewed as a transitional means of treatment for HCW because they found that practice with small-scale incinerators resulted in unacceptable cancer risks under medium usage (two hours per week) or higher (Batterman, 2004) due to exposure to dioxins and furans from small-scale incinerators.

- » Dig a pit 1-meter square and 2 to 5 meters deep (The bottom of the pit should be 2 meters above water level. Consult the local water engineer or water authority for information about the location of the water table.)
- » Fence in the area to keep out animals, waste pickers, and children
- » Dispose of the contaminated waste in the pit and cover the waste with 10 to 15 centimeters of soil each day. (The final layer of dirt should be 50- to 60-centimeters thick and compacted to prevent odors, to keep from attracting insects, and to keep animals from digging up the buried waste.)
- » Depending on the volume, such a pit should last for 30 to 60 days
- » When the level of the waste reaches within 30 to 50 centimeters of the surface of the ground, fill the pit with dirt, seal it with concrete, and dig another pit
- Burning in a pit can be used for combustible and noninfectious waste such as paper. This should be carried out in a simple pit hole and not in the open. Crude tipping or disposing of waste in open sites should be avoided, because it poses infection risks and fire hazards, produces a foul odour, attracts insects, and is unsightly.
- The public health officer shall receive waste and manage it as per MOH guideline and NEMA regulation.

Waste from commercial properties, officers, factories, industries, and other public places

- All waste generated from above entities shall be treated as potentially infectious.
- The owner/occupier/manager/caretaker shall provide adequate appropriate colored leak-proof liner bags / containers to such public places as per MOH guideline.
- The public health officer shall supervise the safe management of the infectious waste generated from such public places in consultation with relevant actors.
- The owner/occupier/manager/caretaker shall ensure that waste is managed by the licensed HCW handlers as per the NEMA regulation.
- The infectious waste shall be disinfected daily by the owner/occupier/manager/caretaker as per MOH guideline.
- When the bag is two-third (2/3) full, the waste shall be disinfected as per MOH guideline, tied properly, labeled the bag as infectious waste, and placed in a designated area for collection in a sanitary lane.
- Potentially, infectious waste shall be transported, treated, and disposed according to the NEMA regulation.
- All vehicles, conveyors, vessels, and receptacles used in the holding, storage, transportation, treatment, and disposal of the potentially infectious waste shall be disinfected in line with MOH guideline.

COVID-19 waste management

MOH, Kenya formulated the specific procedure of "Safety management and disposal of safety products in prevention of spread of COVID-19" in April 2020, applying to communities, public places healthcare facilities and COVID-19 isolation centers. In principle, COVID-19 waste should be managed by the policy and guidelines mentioned above. Waste management related to COVID-19 is specifically guided as follows.

Waste from households

- All waste generated from households where there is a suspected or confirmed COVID-19 cases must be segregated and stored in leak-proof liner bags / container labelled "infectious waste".
- The public health officer shall provide the leak-proof liner bags / container from nearest health facility to such households as mentioned above.
- The public health officer shall supervise safe management of the infectious waste from suspected or confirmed COVID-19 households.
- The infectious waste from the suspected or confirmed COVID-19 shall be disinfected daily by the household as per MOH guideline.
- When the waste liner bag is two-third (2/3) full, waste shall be disinfected as per MOH guideline, tied properly, labeled the bag as infectious waste, and placed in a designated area for collection.
- Infectious waste from the suspected or confirmed COVID-19 households shall be transported to the nearest public health facility according to NEMA regulation.

Waste from quarantine centers

- All waste generated from quarantine centers shall be treated as infectious waste.
- The administrators and managers shall provide adequate appropriately coloured leak-proof liner bags / containers to quarantine centers.
- MOH shall supervise the safe management of the infectious waste from quarantine centers.
- The administrators and managers shall ensure that waste is managed by the licensed HCW handlers as per NEMA regulation.
- The infectious waste from quarantine centers shall be disinfected daily by administrators or managers as per MOH guideline.
- When the bag is two-third (2/3) full, the waste shall be disinfected as per MOH guideline, tied properly, labeled the bag as infectious waste, and placed in a designated area for collection.
- Infectious waste collected from the quarantine centers shall be transported, treated, and disposed according to NEMA regulation.
- All vehicles, conveyors, vessels, and receptacles used in the holding, storage, transportation, treatment, and disposal of the infectious waste shall be disinfected in line with MOH guideline.

Sri Lanka

Guidelines for COVID-19 waste management from households and quarantined locations

The Government of Sri Lanka formulated the "Interim guideline for management of solid waste generated by households and places under self-quarantine due to COVID-19 outbreak³³" in March 2020. The interim guideline is prepared in line with the current solid waste management policy, regulation and standards, but provisions have been made to accommodate the specific needs of the health emergency situation prevailing at present, for local authorities in Sri Lanka to manage waste.

General instructions for local authorities and stakeholders

The first step of the COVID-19 waste management plan is to identify households, places and persons subjected to self-quarantine, and to deliver special service to those places and households. For providing adjusted waste collection services, the local authorities have to allocate following resources.

- Arrange a separate vehicle for waste collection and transport
- Have an appropriate number of waste handling crews
- Supply appropriate waste collection bags
- Assign public health officers to advise households on-site disposal, and to train and supervise activities of waste handling by residents and collection crews in the local authority
- Give instructions to the households undergoing self-quarantine not to practice illegal open dumping (stress the possibility of taking legal action against such cases)
- Temporarily stop the acceptance of waste for the recycling centers or shops until COVID-19 pandemic ceased if patient or contamination has been recorded in the designated area.
- Temporarily stop the training programs, site visits and study tours to waste management sites that are being operated by local authority until COVID-19 pandemic ceased.
- Strictly prohibit entry of people and animals to dumpsites and scavenging on waste.
- Appoint a responsible officer to implement waste management activities and instruct them to implement these measures with the assistance of other stakeholders.

Instructions for households/places subjected to quarantine

Householders must make maximum effort to minimize waste generation. Limiting excessive use of packaging materials, tools, utensils, and consumables can support

waste minimization. Households are advised to follow waste reduction guidance and instructions given by the local authority and public health officer. MSW generated from households and the self-quarantine places with COVID-19 positive cases or people who are thought to be infected are guided to separate into a minimum of 3 categories.

- Kitchen and food waste (organic waste)
 - Waste generated from food processing, leftover after consumption, spoiled/discarded foods
- Non-biodegradable waste
- Special waste
 - Waste and potentially contaminated items such as face masks, masks, gloves, handkerchiefs, tissues, sanitary pads, diapers, and other materials contaminated by body fluids of residents

The guideline instructs MSWM for households and the self-quarantine places with COVID-19 positive cases or people thought to be infected, as shown in the table below.

Occupational health and safety of waste handlers

Local authorities shall supply appropriate PPE for all persons involved in waste collection, transport, and disposal. The PPE includes special workwear (overalls), masks, gloves, shoes/boots and an apron or disposable work clothing. Sanitary workers should be instructed to use PPE properly and shall be monitored. The waste handlers and supervisors must be suitably briefed and supported regarding the nature of the waste and the necessary safety procedures to support them to carry out their tasks. They should have suitable PPE and each day of special service a fresh set of PPE must be worn. Overalls can be reused after thorough cleaning and disinfection. It is the responsibility of the local authority to provide necessary PPE.

Waste handlers should be instructed to maintain social distance of at least one meter during their house-to-house collection activities. The special waste collection vehicle shall be disinfected at the final disposal site right after unloading the waste (spraying a disinfectant solution, i.e. 70% alcoholic disinfectant/ laundry soap solution/liquid/ toilet cleaners). The cleaning shall be carried out for each collection trip. The waste collection workers shall be supplied with an adequate amount of hand sanitizers and cleaning agents (soap/ disinfectants) to wash their hands each time they pick up special waste from a quarantine house/place. Collection crews shall be instructed to minimize their contact with external environment (strictly advise them not to drink tea/water, chewing betel nut and smoking or visiting shops) during the collection of special wastes. They should be advised not to touch their face or the mask while collecting special wastes.

Table. Operations according to the waste types in households and places subjected to quarantine

Waste management flow	Organic waste	Non-biodegradable waste	Special waste
Storage at source	Collect into a leakproof polythene bag placed inside a plastic/metal basket with lid.	Collect in a HDPE (minimum thickness of 25 microns or 100 gauge) or LDPE (minimum thickness of 55 microns or 250 gauge) polythene bag (If local authority intends to separate non-biodegradable waste into two categories as recyclables and residual waste, waste is to be placed in separate two bags.)	Collect in a leak-proof yellow color HDPE (minimum thickness of 25 microns or 100 gauge) or LDPE (minimum thickness of 55 microns or 250 gauge) polythene bag. The bag is then placed in another similar yellow bag.
	Those bags are to be located in a secure place outside of the reach of children and animals until discharge or disposal.		
Transportation	Collected by special waste collection service, whenever possible Only accept organic waste that has been kept for 3 days period in place Bags are collected without opening Bags can be disinfected prior to loading into vehicle	Collected by special waste collection service, whenever possible 3 days storage before collection Separated recyclables can be handed over to recyclable collection scheme under guidance of Public Health Inspector/Medical Officer of Health and local authority	Collected by special waste collection services only 3 days storage before collection Disinfection of bags prior to load into vehicle
Treatment for COVID-19 waste	Not to be placed into compost facility nor allowed to be scavenged by any person or animal Incinerate if a facility available	Incinerate if a facility available	Mandatory thermal treatment (i.e. incineration) for special waste if not available, waste should be handed over to accredited clinical waste handler for safe treatment through combustion
Disposal (On-site)	Households having adequate space are recommended to construct a waste disposal pit to dispose all organic waste on-site. Minimum 2 ft deep secured with bunds around the pit Waste is to be disinfected prior to disposing into the pit	Consider on site disposal due to unavailability or difficulty of providing normal waste collection service 2 x 2 x 2 ft pit Waste is to be disinfected prior to disposing into the pit Waste should be covered by 6-inch-thick soil layer	N/A
Disposal (Off-site)	Sanitary landfill if available Emergency land disposal 8 ft deep, must not reach underground water level Prevent rainwater entering by soil ridge and furrows Protected from reach of people and animal Waste is to be added with disinfected prior to disposal Disposed waste should be covered by soil		

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