Planning of single-used mask waste containers as personal protective equipment: a case study of Jakarta City station

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Article Info

Article history:

Received Aug 18, 2021
Revised May 12, 2022
Accepted Jun 20, 2022

Keywords:

Container
COVID-19
Personal protective equipment
Waste management

ABSTRACT

During the COVID-19 pandemic, the use of masks is an obligation for everyone to maintain the transmission of the virus to fellow humans. Public places such as stations are one of the locations that may produce single-use masks as personal protective equipment waste. This study aimed to plan the most appropriate type of infectious waste container for disposable masks. Storage with the addition of ultraviolet lamp technology is one way to increase virus removal efficiency compared with no further processing. In this study, it was estimated that the most appropriate container volume is with a capacity of 50 L per station. The collection must be done every 24 hours; the estimated cost for one container can reach IDR 1,988,900. This planning can reduce the amount of mask waste used for the environment and reduce the burden applied to these places at the end.

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1. INTRODUCTION

COVID-19 or Coronavirus disease caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). It is is a virus that can spread widely and quickly and be transmitted from human to human [1]–[3]. Several coronaviruses can cause respiratory infections ranging from the common cold to more severe illnesses [4], [5]. The most common symptoms found during this virus were fever, dry cough, and fatigue. Some people who are infected with this virus also have very mild symptoms.

The transmission of the COVID-19 virus can be through droplets from the nose or mouth that come out when a person with COVID-19 coughs, sneezes, or even talks. Droplets that have been infected with this virus can land on objects around the person [6], [7]. Other people can become infected simply by touching an object or surface exposed to the droplets and then touching their eyes, nose, or mouth. Coronavirus can survive on the surface of objects for a long time. For example, the influenza virus can survive up to on plastic and stainless steel 24–48 hours than on paper and tissue 6–8 hours [8]. However, this virus can be cleaned from the surface of objects by using a disinfectant. It is also highly recommended to wash hands regularly with soap and water or clean hands and surfaces around us with an alcohol-based antiseptic.

The use of masks recommended by World Health Organization (WHO) to reduce transmission of the COVID-19 virus is to use medical masks and respirators for health workers [9] WHO itself mentions that there is no convincing scientific evidence of the possible benefits and disadvantages that are considered by using cloth masks [9]. However, because it is difficult to buy or find medical masks in some countries, it is permissible to use cloth masks to prevent the transmission of the COVID-19 virus effectively and use masks when going out of the house [10], [11]. The single used medical masks should not be more than four hours [12]. Medical mask users should replace the medical mask when it is wet, dirty, or damaged. Because of masks waste should not be held and removed due to viruses or droplets from infected people.

Infectious waste is goods or materials left over from activities that are not reused and can be contaminated by infectious substances or in contact with patients or staff at Health Facilities who handle COVID-19 patients. Waste in the biohazard category is a type of waste that is very harmful to the environment. Many viruses, bacteria, and other harmful substances must be destroyed immediately [13]. Several factors must be considered in collecting or storing waste: the type of storage facilities used, the location of the storage facilities, health, and the beauty of the environment collection method used [14]. Containerization of domestic infectious waste can be controlled in several stages. Once the waste container has reached 3/4, it should be tightly closed so as little air inside as possible. Then the plastic bag must be lined/placed in the second bag. The second bag should not be too full to ensure the bag is tightly closed and does not break; waste does not need to be compressed to add additional space. This study aims to plan a waste container for disposable personal protective equipment by taking a case study of the Mass Rapid Transit station in the city of Jakarta.

2. RESEARCH METHOD

2.1. Location and time of research

This research was conducted during the COVID-19 pandemic, precisely from September to December, 2020. The research location was in Jakarta, Indonesia. The sampling location for the planning of infectious waste containers is carried out at the Dukuh Atas Mass Rapid Transit (MRT) station. This location was chosen considering that this area is the center of the change in public transportation in Jakarta, so it is estimated that this location is more crowded than other stations.

2.2. Data collection and analysis

This research was conducted by conducting a literature study by following the existing conditions. Then data on waste generation was also obtained from previous literature studies. The data obtained is then processed based on the research object's needs, namely the Dukuh Atas MRT station. Determining the standard of accommodation based on existing regulations in Indonesia and literature reviews from other countries. Determination of infectious waste container design.

3. RESULTS AND DISCUSSION

3.1. UV for infectious waste treatment

Ultraviolet (UV) light is one of the rays with radiation power that is lethal to organisms. Its destructive properties make UV light commonly used in aseptic conditions. UV light ranges from 4 nm to 400nm, while the highest efficiency for controlling viruses is at a wavelength of 365 nm. UV light has very low penetration power, so UV light is only effective for controlling the virus on surfaces that are directly exposed or on the surface of a medium that is transparent to UV light. Maximum absorption of UV light in viral cells occurs in nucleic acids so that it causes damage to the ribosomes, and this causes mutations or cell death [15]. Ultraviolet is a part of the electromagnetic spectrum and does not require a medium to propagate. Ultraviolet has a wavelength range between 400-100 nm between the X-ray spectrum and visible light [16].

Ultraviolet radiation is an energy source that can penetrate the cell walls of microorganisms and change the composition of nucleic acids. Ultraviolet absorption by Deoxyribonucleic acid (DNA) can cause these microorganisms to be unable to replicate due to the formation of double bonds in pyrimidine molecules. Ultraviolet radiation absorbed by proteins on the cell membrane will cause damage and cell death [16]. The mechanism of action of ultraviolet light is to absorb nucleic acids without causing damage to the cell surface, and absorbed energy causes bonds between adjacent thymine molecules. Causes the formation of thymine dimers to function nucleic acids is disrupted and results in bacterial death [15]. The effect of ultraviolet radiation on human health and the environment, the wavelength range as shown in Table 1.

Research conducted by Andrea *et al.* showed that the removal efficiency of UV Sanitizer Covent (UVSC) reached 99% for virus removal. Among physical methods or non-touch technology, ultraviolet C (UVC) radiation is widely used as a disinfectant in hospitals. It is suitable for sterilizing operating rooms and ICUs as well as medical equipment.

Table 1. Description of commonly used UV types

UV type	Description
UV-A	with a wavelength of 380-315 nm, which is often referred to as longwave/blacklight.
UV-B	with a wavelength of 315-280 nm, which is often referred to as a medium wave
UV-C	with a wavelength of 280-100 nm, which is often called a short wave.

3.2. Planning

Design planning requires calculations to get a design that fits the needs and production capacity. The volume of infectious waste at the MRT station was calculated using data on the generation of infectious waste at the MRT station per day per station. This study uses data from previous research, which states that the station's infectious waste generation can reach 0.65 kg/day. The calculation of the mask container is presented in Table 2.

Table 2. Details of the calculation of the design of the waste mask container at the MRT Station

Parameters	Value
Mask waste dimensions (a)	= 17.3 cm x 9.5 cm x 0.1 cm
	= 16.5 cm^3
	= 1.65 x 10^{-5} m^3
Mass of mask (b)	= 2 g
	= 2 x 10^{-3} kg
The density of mask waste (c)	= 8.25×10^{-3} m^3/kg
Waste generation (d)	= 0.65 kg/day
Mask waste generation by volume (e)	= c x d
	= 8.25×10^{-3} m^3/kg x 0.65 kg/day
	= 5.36 L/day
The volume of the mask waste container in the MRT station (f)	= e x Safety factor
	= 5.36 L/day x 7
	= 37.52 L
Free space minimum need (g)	= 1/4 x f
	= 1/4 x 37.52 L
	= 9.38 L
The total volume of the mask waste container in the MRT station (h)	= f + g
	= 37.52 L+9.38 L
	= 46.9 L ≈ 50 L

The calculation of the volume obtained is 46.9 L, and this is also done to consider the maximum amount of waste-filled is of the total volume of the container. Where seven is the safety factor used in determining if there is a container that exceeds the carrying capacity. This considers the efficiency of officers and applicable regulations in Indonesia. The mask waste container is divided into two parts, namely the inside and the outside. There is a tube-shaped trash can measuring 50 litres on the inside and serves to accommodate mask waste. The outside of the container is in the form of a block and has a biohazard symbol and aims to protect the trash can and place a microcontroller and ultraviolet lamp. The dimensions of the mask waste container are.

The microcontroller is a digital electronic device with input and output and control with programs written and deleted. The microcontroller works to read and write data [17]. Meanwhile, according to Suprapto [18], the microcontroller is an example of a simple computer system that falls into embedded computers. Microcontroller components can be in the form of processor, memory, I/O, clock, and others. One type of microcontroller that is commonly used is the Arduino microcontroller. Arduino is an electronic kit or open-source electronic circuit board with the main component: a microcontroller chip with the Advanced Versatile RISC (AVR) type. The goal is to embed a program on the microcontroller so that the electronic circuit can read the input, process the input, and then produce the desired output. In general, Arduino consists of the first two pieces of hardware in the form of an open-source input/output (I/O) board and Arduino software which is also open-source, including the Arduino integrated development environment (IDE) software for writing programs and drivers for connecting to a computer [19], [20]. Based on these considerations, the budget plan needed in this plan can be seen in Table 3.

The difference between the second alternative and other alternatives is the use of an ultraviolet sterilizer lamp which functions as a technology to sterilize the mask waste container from bacteria or viruses contained in the waste disposed of by station users. In planning, this container also requires additional tools in UV light located in the trash to sterilize waste. So that the additional costs for operational purposes required are four pieces of personal protective equipment (PPE) for employees with waste disposal calculations carried out once a week because the stored waste has been sterilized. The infectious plastic with the same amount as employee PPE, which is four pieces per month. The cost of using electricity for a microcontroller trash can containing UV light is a total of 12.24 kWh, and the basic electricity tariff in 2020 is Rp. 1,352/kWh.

Table 3. Budget plan used in designing the waste mask container

No	Tools and Materials	Unit price (IDR)	Unit quantity	Unit	Total price (IDR)
1	Arduino uno R3	52,000	1	unit	52,000
2	Project board/Breadboard	20,000	1	unit	20,000
3	IR touchless sensor	76.000	1	unit	76.000
4	50L trash can (40 cm x 74 cm)	125,000	1	unit	125,000
5	Servo gear motor	96,000	1	unit	96,000
6	Jumper cables (20pcs)	15,000	2	unit	30,000
7	Stainless steel plate (0.4 mm x 1.2 m x 2.4 m)	424,200	3	sheet	1,272,600
8	Elbow bracket (20 mm x 20 mm)	3,500	24	unit	84,000
9	Bolt	1,000	50	unit	50,000
10	Myrrh	370	50	unit	18,500
11	Stickers	5,000	3	sheet	15,000
12	UV lamp sterilizer	149,800	1	unit	149,800
Total					1,988,900

Infectious waste containers are lined with coloured plastic bags different for easy transport of waste and cleaning containers. Waste collection from the container is carried out 3/4 full or at least once in 24 hours. The collection is carried out in the following steps: opening the lid of the trash can then placing the bag in a container for transportation. After collecting, officers are required to clean the entire body or at least wash their hands thoroughly with soap and running water. Personal protective equipment such as goggles, boots, and aprons are used to be disinfected as soon as possible in a disinfectant solution. At the same time, masks and gloves are disposed of in special solid waste containers. Special solid waste must be stored in the temporary inflectional waste/waste treated like an infectious waste.

Medical infectious waste is put into a container/bin lined with a yellow plastic bag with the symbol "biohazard". Only solid medical infections waste can be put in a medical infection waste plastic bag. If there is liquid in it, the liquid must be disposed of into the provided wastewater reservoir or a hole in the sink or toilet that drains into the wastewater treatment plant (WWTP). After full or 12 hours at the longest, the inflectional waste/waste is packed and tied tightly and disinfected. Officers must wear full PPE. The collection of solid medical infectious waste to the temporary inflectional waste storage is carried out using special means of transportation for infectious waste and officers using PPE. Provide the Infectious symbol and label and the caption "Highly Infectious Waste". Infectious waste tied up every 12 hours in a container/bin must be transported and stored temporarily or in a special place. Packaging for COVID-19 infectious waste is carried out by disinfection by spraying disinfectant on the bound plastic waste.

The container is disinfected with 0.5% chlorine, lysol, carbolic acid, and others [21]. Disinfection with 0.5% chlorine disinfectant at temporary storage thoroughly, at least once a day. Infectious waste must be tied up with a disinfectant using a chlorine-based disinfectant with a concentration of 0.5% when they are transported to the processor. If processing cannot be carried out directly, the waste can be stored using a freezer/cold storage which can be set at a temperature 0ºC in the temporary storage.

The waste container will be placed with a banner indicating using a microcontroller-based container that can equip with sensors to make it easier for users to use it. This banner also provides preventive measures for COVID-19 transmission. Microcontroller-based trash bins equipped with this sensor will be placed near the entry and exit counters towards the station. The placement of the mask waste container is because the location is a strategic location that many people primarily traverse. In addition, the location for placing the trash bin was chosen because it is a link between the BNI airport station and the Dukuh Atas station. The mask waste container will later be made a line around the container as a sign for the container's layout, as shown in Figure 1. Infection waste treatment can use incinerators, autoclaves, microwaves, or in an emergency; such equipment is exempted from having a permit.

The prevention of good infectious waste is also an effort to prevent the bad environmental impacts due to the use of PPE during the COVID-19 pandemic. Several studies in Indonesia have also reported environmental impacts caused by the COVID-19 pandemic, such as the presence of PPE as a new composition in marine debris [22]–[24]. During the pandemic, it also causes the pattern of waste generation to change, which means that continuous efforts are needed to reduce the environmental impact due to the COVID-19 pandemic [25]–[27]. Prevention of cradle is the best effort in reducing the amount of waste, such as sorting from waste sources, including good containers. Details of station-specific mask waste container design as shown in Figure 2.

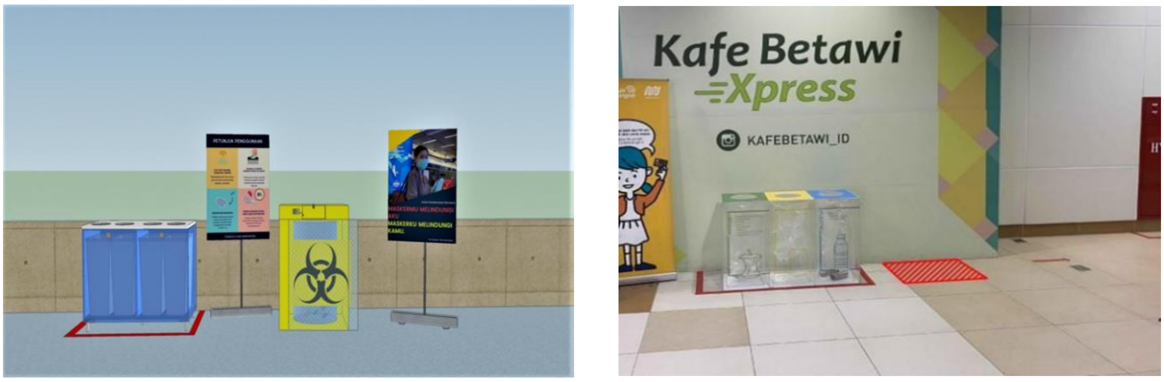

Figure 1. Details of the laying of the mask waste container

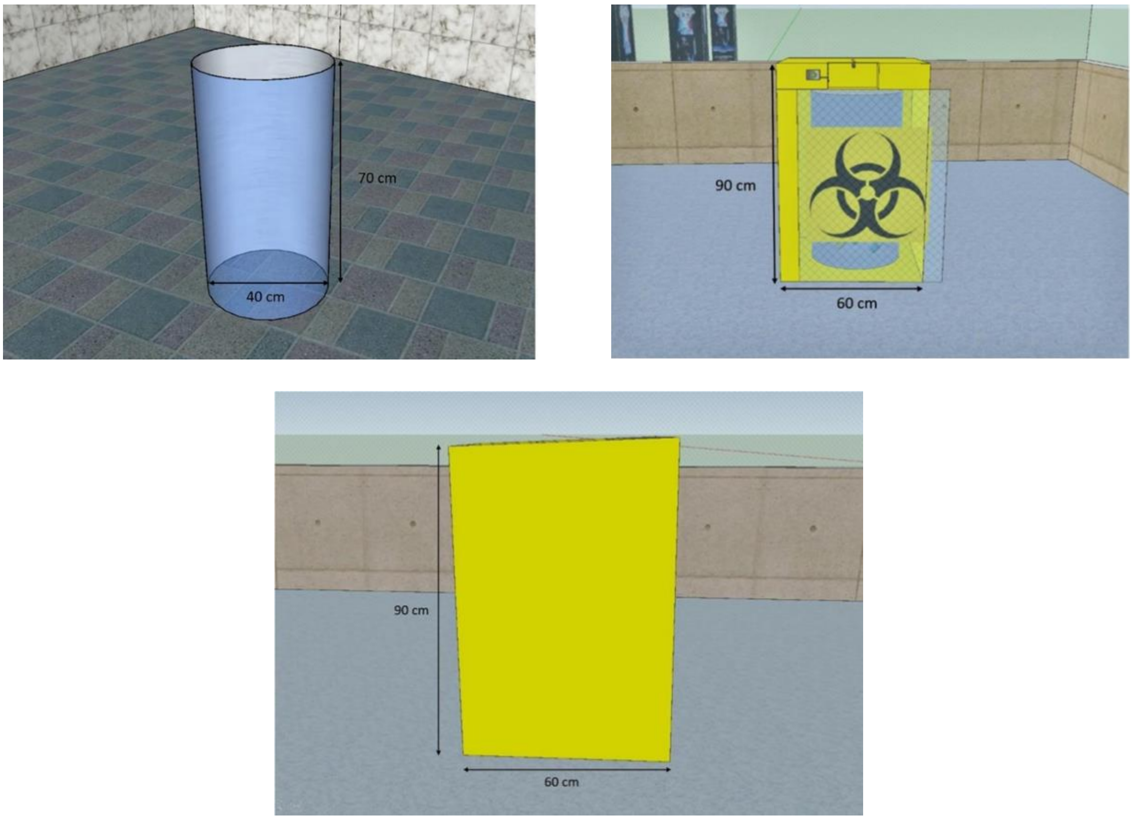

Figure 2. Details of station-specific mask waste container design

4. CONCLUSION

As a preventive measure in the transmission of COVID-19 through mask waste at the MRT station. A mask waste container was made by collaborating with microcontroller-based automatic technology equipped with ultrasonic sensors that detect people's arrival so that the lid of the trash can opens and closes automatically. The container with a capacity of 5.36 L with a waste generation of 0.65 kg/day is equipped with a disinfection facility with ultraviolet light technology on the upper side of the infectious waste container room. The discarded mask waste is discarded can be directly sterilized using ultraviolet light technology with a removal efficiency of 99%. The impact of this research design is to apply public facilities trash bins everywhere in DKI Jakarta. With this, it will also reduce the disposal of single-use masks into the open environments such as rivers, beaches, marine or surrounding land. More research should be done to see the benefits of having this trash can to see it has benefits for acceptance and application to the public.

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