Sainteknol Vol 20, No 2 (2022): December 2022

https://journal.unnes.ac.id/nju/index.php/sainteknol

Selection of Infectious Waste Storage from Disposable Personal Protective Equipment in the Era of the Covid-19 Pandemic

Annisa Kamilia Nastiti[1], Fajar Satrio Utomo[2], Cyntia Aulia Putri[3], Lisa Maharani[4], Michael Yosafaat[5], Mega Mutiara Sari[6], I Wayan Koko Suryawan[7]

Environmental Engineering Study Program, Faculty of Infrastructure Planning, Universitas Pertamina, Indonesia

Email:

Abstrak

Disposable personal protective equipment (PPE) waste is one type of waste that can be found in public facilities such as stations. Improper storage can create new impacts and contaminate waste that does not have the same properties. The purpose of this study is to analyze various alternatives to the best disposable personal protective infectious waste disposal facilities. The method used in the selection of alternatives is the Analytical Hierarchy Process (AHP). The three alternatives provided based on the literature review are hand sanitizer (A1), ultraviolet lamp (A2), and disinfectant spray (A3). The criteria used in the selection of alternatives are virus removal in storage, equipment maintenance, and electricity consumption costs. Analysis of the weight of the criteria shows that the highest weight is in the criteria for virus removal in the container. The results of the weight assessment show that alternatives A2 and A3 have values of 0.499 and 0.406, respectively. The use of virus removal tools is more important than the addition of hand sanitizer facilities which only have a weight of 0.095.

Keywords: Alternatives , COVID-19, Waste, Infectious, Pewadahan

INTRODUCTION

The COVID-19 virus first appeared in Wuhan, Hubei Province from December 2019 to January 2020 (Hasnain et al., 2020; Luo et al., 2020; Zheng et al., 2020). On March 12, 2020, WHO declared COVID-19 as a pandemic, the COVID-19 virus caused by the *Severe Acute Respiratory Syndrome Coronavirus-2* (SARS-CoV-2) virus. In Indonesia, the increase in the number of cases of covid-19 positive patients began to soar until in July 2021, the virus began to enter Indonesian territory. The SARS-CoV-2 virus can spread through liquid droplets of people who are positively affected by COVID-19, spread can occur when coughing or sneezing and this virus can survive up to 9 days on the surface of objects (Pagliano & Kafil, 2020; Santarpia et al., 2020). So that this corona virus can quickly spread and as a preventive measure it is recommended to keep your distance, wash your hands every 4 hours, maintain body immunity by consuming healthy food and regular exercise and always use a mask when going out of the house or meeting with someone.

During the pandemic, there was a difference in the categories of solid waste produced by urban communities (Ruslinda et al., 2020; Suryawan et al., 2021). Mask waste, which is currently increasingly used during a pandemic, can cause various problems, threats to health factors and also the community environment. Several studies in Indonesia have found personal protective equipment waste including masks to be disruptive waste in marine ecosystems (Cordova et al., 2021; Sari, Inoue, et al., 2022; Septiariva et al., 2022). Some ordinary people still do not understand how to deal with disposable mask waste, especially how to dispose of disposable masks should be managed specifically (Elfrida & Junaida, 2020).

Masks that have been used by humans are usually contaminated by droplets that have the possibility to become a means of transmitting the COVID-19 virus. Therefore, discarded masks require a special place so that they are not contaminated with other waste and can be handled in accordance with applicable procedures. In public facilities in the capital city of Jakarta, there is a need for infectious waste (mask waste and tissues exposed to droplets), people who use public facilities are sometimes reluctant when they have to dispose of masks that have been used during their activities because they do not know what to dispose of the masks and also there are no adequate facilities for the disposal of mask waste provided in public facilities in the capital city of Jakarta (Ardiana et al., 2020; Sari, Yosafaat, et al., 2022).

With the various types of infectious waste disposal that exist, an analysis of the best alternatives is needed. One method that is often used in the environmental field is the Analyric Hierarchy Process (AHP) (Aldilla et al., 2016; Binhar et al., 2020; Pearl & Trihadiningrum, 2014). Thus, the purpose of this study is to analyze alternatives to the containment of infectious waste of disposable personal protective equipment during the COVID-19 pandemic using the AHP method.

METHOD

This research was conducted from September 2020 to January 2021. The data collection used came from a literature review which was then processed by a descriptive method and quantifiably calculated using the *Analytic Hierarchy* Process (AHP) method.

AHP is a decision-making system using mathematical models. AHP helps in determining the priority of several criteria by conducting a *pairwise comparison* analysis of each criterion (Saaty, 2003). The end result of the AHP process is the priorities of the alternatives that are the choice. The way AHP works is by simplifying a complex problem that is unstructured, strategic and dynamic into parts. The working principle of AHP is as follows (Saaty, 2004) :

1.Define goals/objectives, criteria and alternatives to problem solving.
2.Develop a hierarchy of criteria and alternatives.
3.Provide alternative values and criteria.
4.Checks the consistency of alternative assessments and criteria.
5.Determining the priority of criteria and alternatives

RESULTS AND DISCUSSION

The design of a special infectious waste storage for disposable personal protective equipment is needed to maintain public safety, especially from the spread of the COVID-19 virus (Ardiana et al., 2020). The use of disposable personal protective equipment is one of the new problems in the era of the COVID-19 pandemic. The main purpose of the settlement is to avoid the occurrence of scattered waste so that it disturbs the environment in terms of health, cleanliness and aesthetics (Sulistyono, Djoko. 2013). There are several factors that must be considered in waste storage activities according to the type of storage facilities used, the location of placement of storage facilities, the health and beauty of the environment and the collection methods used (Tchobanoglous & Vigil, 1993).

Ultraviolet (UV) light is one of the rays that has a lethal radiation power for organisms. Lethal properties that make UV rays commonly used in places that have aseptic conditions. UV rays have certain wavelengths that can be categorized as UV A, UV B, and UV C (Sofiyah & Suryawan, 2021). UV light has a very low penetrating power, so UV rays are only effective for controlling viruses on surfaces that are directly exposed to or are on the surface of a medium that is transparent to UV rays. The maximum absorption of UV rays in viral cells occurs in nucleic acids, so that this causes damage to ribosomes, this causes mutations or cell death (Ariyadi & Dewi, 2009). 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 which is between the X-ray spectrum and visible light (Okik Hendriyanto, 2010). Research that has been carried out (Guridi et al., 2019) shows that the uvsc (UV Sanitizer Corvent) removal efficiency reaches 99% for virus removal. Among the physical methods or touchless technologies, ultraviolet C (UVC) radiation is widely used as a disinfecting material in hospitals, such as sterilization of operating rooms and ICUs, and medical equipment.

The use of disinfectants can be carried out by rubbing or spraying disinfectant solutions on the surface of objects. Disinfectants are commonly used in the elimination of pathogenic microorganisms (Hasnaningrum et al., 2021). Use with the spray technique is used to control the amount of antimicrobials and viruses in a high-risk room. In hard-to-reach rooms usually used ultraviolet rays with a certain wavelength. Antiseptics, antibiotics and disinfectants in their use have the difference that antibiotics are used to kill microbes in the body, while disinfectants are used to kill microbes in inanimate objects. Antiseptic is a recommendation in the event of a disease epidemic so that it can 10 slow the spread of the disease (Djide & Sartini., 2008).

As an effort to prevent environmental and public health impacts, new innovations are needed that collaborate on microcontroller-based automated technology equipped with ultrasonic sensors that function to detect the arrival of people who want to dispose of mask waste. The sensor will send a signal to the microcontroller for processing, so that the lid of the trash can open and close automatically. The purpose of using sensor technology is to eliminate the amount of virus spread from direct contact with many people.

There are three alternatives proposed in this study (Figure 1). In alternative 1, where there is no disinfection in the container, the absence of microorganism removal occurs. In alternative 2 in the form of storage using ultraviolet light, it can eliminate the virus as much as 99% (Guridi et al., 2019). Also, alternative 3 in the form of storage by using antiseptic aerosol liquid to disinfect, can set aside microorganisms as much as 70% (Elisanti et al., 2020). The alternative can be seen in Figure 1.

Alternatif 1

- In the first alternative, the infectious waste container is only a container with the addition of a hand sanitizer facility in addition to the infectious waste disposal container, so users can use the hand sanitizer facility after disposing of the mask waste they use. The design of the mask waste container in the first alternative is without any disinfection in the waste container section.

Alternatif 2

- In the second alternative, the infectious waste container has a disinfection facility with ultraviolet light technology on the top side in the infectious waste container room, so that mask waste that is disposed of in the container can be sterilized directly with ultraviolet light technology.

Alternatif 3

- In the third alternative, the infectious waste container has a disinfection facility with aerosol spray technology on the top side of the infectious waste container room.
- so that mask waste that is disposed of in the container can be sterilized directly with aerosol spray technology. The aerosol used is a disinfectant liquid with a specification of 70% ethanol.

Figure 1. Alternatives to Infectious Waste Storage at Station Facilities
Source: Primary Data Processed, 2022.

Alternative 1 for the period of refilling the handsanitizer is carried out as much as 4 times a day due to the assumption that the user of the *handsanitizer* is not only the user of the train station who will throw away *the* mask but, other users can also use it. Recharging was carried out 4 times because the average train station user during the pandemic in a day was 2,316 people. The volume of *the handsanitizer* container used is 500 ml and each use is 1 ml / person. Alternative 2 for the period of replacement of ultraviolet lamps is carried out every 2 times a year due to the effectiveness of ultraviolet lamps on for 5000 hours. Alternative 3 for the period of aerosol refilling is carried out 2 times every month with a tank capacity of 16 L and 0.005 L/s once aerosol disinfection spraying.

In determining alternative solutions for designing infectious waste storage, in the first alternative, the container uses a container made of stainless steel plate in which there is an additional trash can container and a trash bag is included in it. The use of the Arduino Uno R3 tool is a microcontroller-based automation technology equipped with ultrasonic sensors that function to detect the arrival of people who want to dispose of mask waste, furthermore, the use of the project board is as an electronic circuit and is used as a prototype of an electronic circuit, with the component project board to be used can be directly stamped according to the available circuit. The next tool is the IR *Touchless Sensor* is an electronic component that will detect the arrival of people who will later dispose of mask waste, then a 20-liter trash can is used as an additional container in it as a collection system. Furthermore, the use of servo motor is a rotary actuator (motor) designed to control the movement of objects in the position of the angle to be determined, the sevo motor is useful as an automatic door drive of the waste container. The next material used is an elbow bracket which is used to unite the sides of the container that will be used as the outermost container, the next is a jumper cable that is used as a connector between electronic components, so that each component can be connected to each other. The next material used is bolts and nuts which are used as adhesive components for the sides of the container to hold each side of the container together, the next material is a sticker that aims to serve as a Standard Operating Procedure (SOP) for the use of a mask waste container which will later be attached to the outer side of the container. The last tool used in the design of the first alternative is the *Touchless Hand Sanitizer* dispenser which is used as an additional facility for station users after disposing of mask waste.

In the first alternative, it does not require additional tools and is only a container. So that the additional costs for operational purposes needed are 120 pieces of employee PPE with the calculation of garbage disposal carried out for 4 hours once a day because there is no waste sterilization process in the trash can, then infectious plastic with the same amount as employee PPE, which is 120 pieces per month. In addition, maintenance in alternative 1 is in the form of disinfection liquid for work areas or tools with an estimated use of 60 liters per month. Disinfection recharges were carried out 4 times because the average train station user during the pandemic in a day was 2,316 people. The volume of *the handsanitizer* container used is 500 ml and each use is 1 ml / person. The cost of using electricity for microcontroller bins with a total of 6.48 kWh and the basic electricity tariff in 2020 is Rp. 1,352 / kWh with the following calculations:

- Microcontroller = 9 volts = 0.009 kW
- Monthly electricity requirement = 720 hours x 0.009 kW= 6.48 kWh
- Monthly electricity price = 6.48 kWh x Rp1,352/kWh = Rp8,760.96

In determining alternative solutions for designing infectious waste storage, in the second alternative, the storage uses a container made of the same stainless steel plate as the first alternative, as well as several components of the same tools and materials to be applied in the second alternative. The difference between the second alternative and the other alternative is the use of an ultraviolet sterilizer lamp which functions as a technology to sterilize mask waste containers from bacteria or viruses contained in waste disposed of by station users (Chotiprasitsakul et al., 2020; Taufieq et al., 2015).

In the second alternative, it requires additional tools in the form of UV light located in the trash can as a tool to sterilize waste. So that the additional costs for operational purposes needed are 4 pieces of employee PPE with the calculation of garbage disposal carried out for one time a week because the waste accommodated has been sterilized, then infectious plastic with the same amount as employee PPE, which is 4 pieces per month. The cost of using electricity for microcontroller bins containing UV light with a total of 12.24 kWh and the basic electricity tariff in 2020 is Rp. 1,352 / kWh with the following calculations:

- Microcontroller = 9 volts = 0.009 kW
- UV lamp = 0.008 kW
- Monthly electricity requirement = 720 hours x (0.009 kW + 0.008 kW)= 12.24 kWh
- Monthly electricity price = 12.24 kWh x Rp1,352 /kWh = Rp. 16,548.48

In determining alternative solutions for designing infectious waste storage, in the third alternative, the container uses a container made of the same *stainless steel* plate as the first and second alternatives, as well as some components of the same tools and materials to be applied in the third alternative. The alternative totiga has the addition of an automatic sprayer device that is useful for disinfectant aerosol containers in the form of 70% alcohol liquid.

In the third alternative, it requires an additional tool in the form of a disinfectant aerosol sprayed in the trash can as a tool to sterilize waste. So that the additional costs for operational purposes needed are 30 pieces of employee PPE with the calculation of garbage disposal carried out for one time a day because there is a waste sterilization process in the trash can and the waste produced produces water from aerosol spray, then infectious plastic with the same amount as employee PPE, which is 30 pieces per month and disinfectant liquid as much as 32 liters as an aerosol liquid that will Sprayed. The cost of using electricity for microcontroller waste bins containing aerosols with a total of 15.84 kWh and basic electricity taritf in 2020 is Rp. 1,352 / kWh with the following calculations:

- Microcontroller = 9 volts = 0.009 kW
- Automatic sprayer = 0.013 kW

• Monthly electricity requirement = 720 hours x (0.009 kW + 0.013 kW) = 15.84 kWh
• Monthly electricity price = 15.84 kWh x Rp1,352 /kWh = Rp21,415.68

Based on the selection of design alternatives using the AHP method, there are several criteria used to analyze each alternative and determine the priority scale of alternatives to be used. The order of the most important criteria used for analysis is the removal of viruses in containers, ease of operation and maintenance, and costs (Table 1). The assessment of the weight of the criteria is carried out by comparing the value of the criteria against other criteria. The value of the virus elimination criteria when compared to practicality in operations will get a value of 5 because virus removal is the top priority in the planning of the storage design. The selection of virus removal criteria is more emphasized because in the design of this storage aims to reduce the transmission of viruses contained in mask waste. So an alternative is needed that has a greater virus elimination. The calculation of the weighting of the criteria in detail can be seen in Table 2.

Table 1. Results of Value Recapitulation for Each Criterion in Determining the Best Alternative to the Selection of Pewadahan Infectious Waste at the Station

Alternative	Virus Removal in storage (%)	Tool maintenance	Electricity usage fee (Rp)
Alternative 1	0	43800 (*handsanitizer*)	8. 760.96
Alternative 2	99	2 (ultraviolet lamp)	16.548,48
Alternative 3	70	24 (aerosol recharging)	21.415,68

Source: Data Processed, 2022.

Table 2. Weight Assessment for Each Criterion Against Criteria

	Virus Removal	Tool maintenance	Cost		
Virus Removal	1,00	5,00	5,00		
Practical in operation	0,20	1,00	0,33		
Cost	0,20	3,00	1,00		
Sum	**1,40**	**9,00**	**6,33**		
NORMALIZED					
	Virus Removal	Tool maintenance	Cost	Weight	Consistency Measure
Virus Removal	0,714	0,556	0,789	**0,686**	3,2840
Practical in operation	0,143	0,111	0,053	**0,102**	3,0327
Cost	0,143	0,333	0,158	**0,211**	3,1001
Total	1,000	1,000	1,000	1,000	
				CI	0,069
				RI	0.90
				C. Ratio	0,077

Source: Data Processed, 2022.

Table 3 is the result of calculations between alternatives and predetermined criteria. All weighting at this stage has met the maximum ratio concession of 0.1.

Table 3. Assessment of Each Criterion of Alternatives to Infectious Waste Storage

Weights for Virus Removal on Existing Containers vs. Alternatives					
	A1	**A2**	**A3**		
A1	1,00	0,14	0,14		
A2	7,00	1,00	2,00		
A3	7,00	0,50	1,00		
Sum	15,00	1,64	3,14		
	A1	**A2**	**A3**	**Weight**	**Consistency Measure**
A1	0,07	0,09	0,05	**0,07**	3,01

A2	0,47	0,61	0,64	**0,57**	3,09
A3	0,47	0,30	0,32	**0,36**	3,07
Total	1,00	1,00	1,00	1,00	
				CI =	0,03
				RI=	0,58
				C. Ratio=	0,05

Weights for the term of mantanance vs existing alternatives

	A1	**A2**	**A3**		
A1	1,00	0,33	0,50		
A2	3,00	1,00	3,00		
A3	2,00	0,33	1,00		
Sum	6,00	1,67	4,50		
	A1	**A2**	**A3**	**Weight**	**Consistency Measure**
A1	0,167	0,200	0,111	**0,159**	3,0233
A2	0,500	0,600	0,667	**0,589**	3,0943
A3	0,333	0,200	0,222	**0,252**	3,0441
Total	1,000	1,000	1,000	1,000	
				CI =	0,027
				RI=	0,58
				C. Ratio=	0,046

Cost Weights vs Existing alternatives

	A1	**A2**	**A3**		
A1	1,00	0,50	0,33		
A2	2,00	1,00	0,25		
A3	3,00	4,00	1,00		
Sum	6,00	5,50	1,58		
NORMALIZED					
	A1	**A2**	**A3**	**Weight**	**Consistency Measure**
A1	0,167	0,091	0,211	**0,156**	3,0426
A2	0,333	0,182	0,158	**0,224**	3,0815
A3	0,500	0,727	0,632	**0,620**	3,2038
Total	1,000	1,000	1,000	1,000	
				=	0,055
				=	0,58
				Ratio=	0,094

Source: Data Processed, 2022.

The final result of weighting shows that alternative 2 has a higher value compared to other alternatives (Table 4). The point on the alternative is not just 0.013 away from alternative 1. UV-C equipment can be a viable disinfection method to be applied routinely in hospitals and laboratories at all times to quickly disinfect objects in contact with patients and health workers, contributing to the control of infection transmission (Guridi et al., 2019). For this reason, the existence of infectious waste treatment facilities from waste sources is important in the current emergency conditions

Table 4. Final Weights For Each Alternative To The Settlement

Alternative	Pewadahan Facility	Weight
Alternative 1	Hansanitizer	0,095
Alternative 2	UV	0,499
Alternative 3	Aerosil Disinfectant	0,406

Source: Data Processed, 2022.

CONCLUSION

Based on three alternatives to infectious waste storage at the station, namely the addition of hand sanitizer facilities, ultraviolet lamps, and disinfectant sprays, it shows that the addition of ultraviolet lamps is more efficient in the criteria for virus elimination, equipment maintenance, and electricity consumption costs. The alternative use of ultraviolet lamps and disinfectant sprays had only 0.013 in AHP analysis. For this reason, the addition of ultraviolet lamps and disinfectant sprays in killing viruses as an effort to provide public safety in carrying out activities in public places.

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