



The Effectivity of Solid Medical Waste Management in Pandemic Era

**Hilda Nur Abidah^{1*}, Hashifah Azatil Ismah¹, Selvi Irmayanti¹, Globila Nurika¹,
Edza Aria Wikurendra²**

¹Faculty of Public Health, University of Jember, Jember, Indonesia

²Doctoral School in Management and Organizational Science, Faculty of Economy Science, Magyar Agrár- és Élettudományi Egyetem, Kaposvár, Hungary

*Corresponding Author. Email: hildanurabidah5@gmail.com

ABSTRACT

Introduction: The increasing of confirmed positive case of SARS-Cov-2 Virus impacts to the need for improvement of health services, especially to the health workers and medical equipment. Along with the importance of regarding need of health service, it causes the rise number of medical waste that leads to health problem crisis. Therefore, this article presents common insight of the effectivity and challenge of medical waste management in Covid-19 pandemic.

Methods: The notion is gained by finding out the source database from Pubmed, ScienceDirect, Google scholar, Researchgate that classified based on the research purpose. The keywords used were: (1) Covid-19 and medical waste; (2) pandemic solid waste; (3) waste and Covid-19; (4) management and pandemics.

Results: An effective method to be applied is sterilizer technology, such as VH_2O_2 dan Stryker STERIZONE VP4, and the development of late waste respirator with the pyrolysis process. The method and the management process is considered, either nationally or internationally, as effective, but still we found challenge to implement the method, as lack of socialisation and support from the functionary.

Conclusion: the method management of solid medical waste can be implemented in the various countries, based on the needs and capability.

Keywords: solid medical waste, waste management, covid-19 pandemic

Article History: Received: 16th March 2021, Revised: 8th August 2021, Accepted: 10th December 2021

Introduction

SARS-Cov-2 virus draws global attention, mainly in health and it is determined as pandemic by World Health Organization (WHO) since March 11, 2020. The enhancement of virus transmission keeps arising, then leads to mortality and morbidity that do not show any reduction. This pandemic is state of emergency of public health and endanger the health population in the world. Since 28 February 2021, SARS-Cov-2 has been

infecting 113,472,187 people and causes 2,520,653 death in the world.¹ World Health Organization (WHO), National Disease Control Center, and local government has recommended the health workers and society to wear personal protective equipment and determine some policies to decrease virus transmission.² The increase number of positive case of SARS-Cov-2 affects on enhancement of health service, especially on health worker and medical equipment.

Along with the importance of the need of health service, it also increases number of medical waste significantly.

Based on the study press about Joint Prevention and Control Mechanism from China state council has found about 468.9 ton of everyday drug waste. Whereas, in Indonesia, particularly at Jakarta has collected 12,740 tons of medical waste since 60 days after the first person infected in that area.² The escalation of medical waste in the world leads to an environmental problem, especially related to managing and the effect. Managing waste without paying attention to effectivity and efficiency, either on arrangement or standardization, could endanger the environment and may increase coronavirus transmission.

Waste material is presumed to contain pathogen (bacteria, virus, parasite, or fungus) in sufficient concentration or in the amount that causes the disease to tenous host, because it is dangerous for health.³ In particular, if the waste is produced by Covid-19 do not get intensive management, as the waste-collecting, management, sterilization, transportation to throw out the waste in a certain place, that brings risk as to the temporary place of leftover virus and cause contamination that affects to unpredictable knock-on effect to health and environment. The

health workers, beggars, or the society who involve directly or not, are risked and they need to be cautious.²

Therefore, this study is needed to appraise the effectiveness of solid waste management in Covid-19 pandemic as the evaluation to minimize Covid-19 infection and the effect for the environment based on process channel of solid medical waste, the effect of solid medical waste accumulation, and the effect SARS-Cov-2 transmission to medical waste in the pandemic era.

Methods

Study selection and quality assessment, The searching literature selection criteria in **Table 1**.

a. Study selection

Based on a literature search through 4 published databases of Pubmed, ScienceDirect, google scholar, research gate using 4 adjusted keywords, the researchers found 4.838 articles relate to the keywords. Subsequently, the researcher found 4.757 duplication articles, with the result that some of them are excluded and left only 81 articles. Then, the researchers did screening based on the title (n=30), abstract (n=22), and full text (n=6) with the topic that is suitable to the literature review.

Table 1. Literature Selection Criteria

CRITERIA	INCLUSION	EXCLUSION
Population (P)	Health services and health instance in the world	Besides health service and health in the world
Intervention (I)	Determining procedure of solid medical waste management	Besides determining the procedure of solid medical waste management
Comparators (C)	None	None
Outcomes (O)	Reduction of environmental risk and enhancement of virus transmission as the effect of less effective solid medical waste management.	The reduction was other than environmental risk and enhancement of virus transmission as the effect of less effective solid medical waste management.
Study Design and Publication type	All type of research design Publication type: open access research article	None
Publication years	After 2019	Before 2019
Language	Indonesian English	Another language than English and Indonesian

b. Quality assessment of the study

After doing analysis to the quality of the methodology in every (n=10) with checklist critical appraisal. On the last screening, ten studies reach more than 50 % score and were ready to do data synthesis, then using 6 articles within the literature review.

Results

The literature review is collected from 4 databases as follows Pubmed, ScienceDirect, Google scholar, and Researchgate using 4 keywords, in the following: (1) covid-19 and medical waste; (2) pandemic solid waste; (3) waste and covid-19; (4) management and pandemics.

Inclusion criteria that are used in literature review searching are (table 1): (1) the article is coherent with the main topic; (2) published in 2020 and 2021; (3) open access and full text; (4) reputable national and international article.

Based on the search result, the total amount of literature review is 6 articles that embrace observational study. The searching flow of the literature can be observed in **Figure 1**. The study tabulation that point out important found in each article can be seen in **Table 2**.

Discussion

The effectiveness of solid waste management method in a pandemic era

Managing solid medical waste in Covid-19 needs to be handled properly, to avoid new sources of infection for humans. Some countries have applied effective technology to manage waste. Research by Neil & John (2021) reports that many countries have adopted decontamination technology and reused personal protection equipment.⁴

The use of sterilizer technology as the VH_2O_2 and Stryker STERIZONE VP4 has been verified by Food and Drug Administration (FDA) under the authority of the Emergency Use Administration (EUA). The use of VH_2O_2 is recommended by other countries to do decontamination of N95 respirator and personal protection equipment. Using VH_2O_2 has been proved effective to disinfect 2.500 N95

respirators per 12-hour shift on 3000–750 ppm hydrogen peroxide. Other research shows that the VH_2O_2 process has fulfilled the requirement of ISO 14937: 2009. The research reports that VH_2O_2 is suitable to sterilize medical equipment. VH_2O_2 process also has a shorter sterilization cycle than other.⁵

The waste management method is carried out by establishing a new waste respirator to decrease Covid-19 infection. There are seven process systems of waste respirators, as follows, pre-processing respirator, pyrolysis, separation of light hydrocarbon, separation of CO_2 , hydrogenation, hydrogen production, and ignition. The pyrolysis process is a decomposition of waste respirators into various hydrocarbons. this process helps mitigation by reducing the emission of greenhouse gas by 59,08% than incineration system.⁶

Other research reports that pyrolysis is the solution to solve the problem of medical waste in the pandemic era. Pyrolysis is done by converting plastic waste to become fuel. It shows that pyrolysis is effective to manage medical waste.

Research by Dharmaraj, et al. (2021) reports that pyrolysis has eminent potential and it is effective as a waste management method.⁷ Pyrolysis is a thermo-chemical process where contaminated materials will be easy to unravel. It can be one of the technology to overcome medical waste inefficient way, it is more simple and easy to change waste into energy products (ready-to-use fuel).

The process of medical waste management in Poland consists of retention, collection, transportation, and tendance of protection equipment the local government has followed the decision of the Ministry of Health and The Head of Cleaning Department about particular guidance to manage protection equipment waste. The local government also prepares an information campaign for the collection companies. Financial support from the government is needed to apply medical waste management. Based on the local government's point of view, the pre-

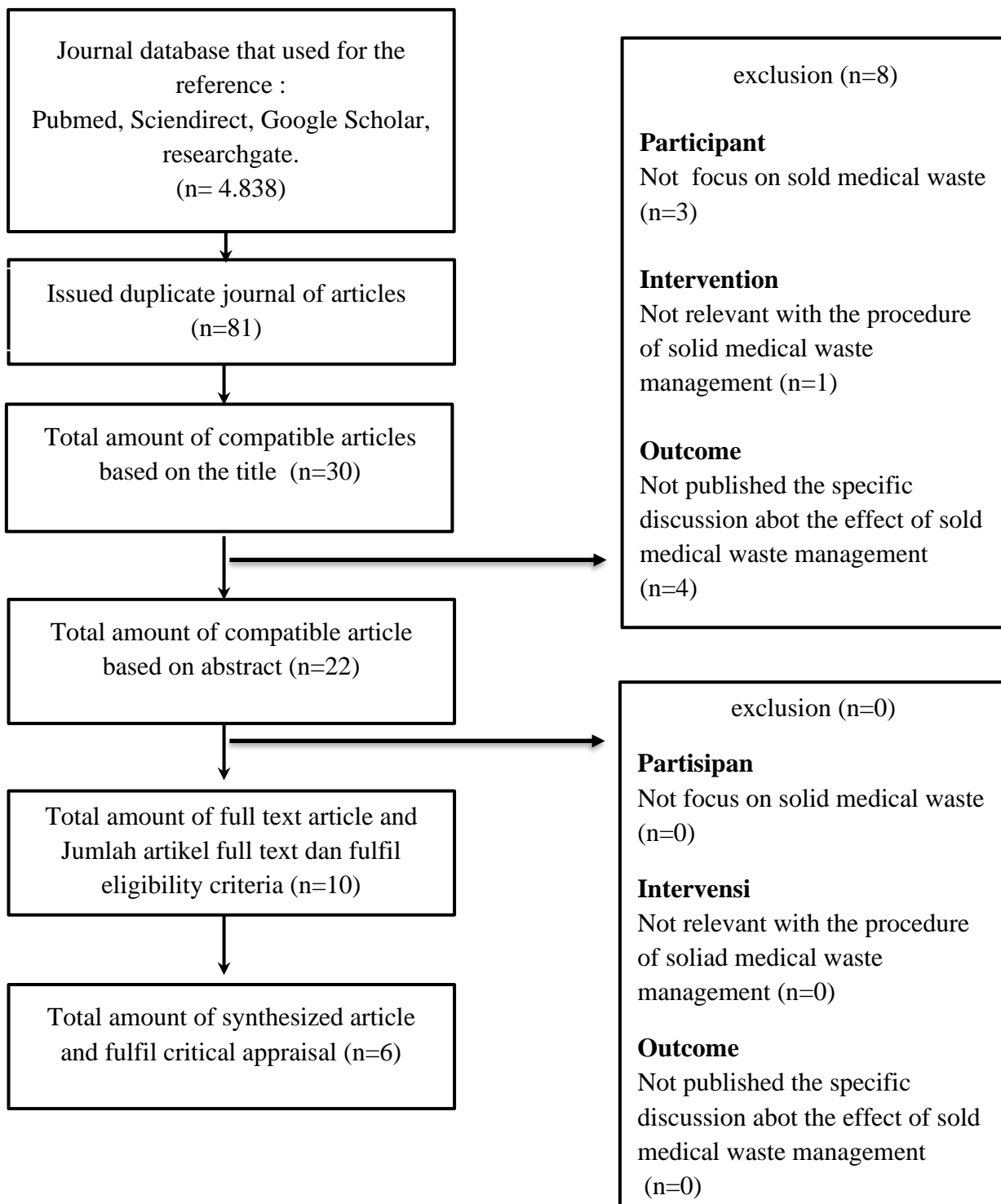


Figure 1. Literature Review Searching Process

Tabel 2. Study tabulation within the literature review

No	Author, Year of publication	Tittle of the journal	Population and Sample	Research Type	Data Collection	Important Found
1	Neil J. Rowan dan John G. Laffey (2021)	Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic – Implications for efficacy, re-use and sustainable waste management	-	Literature review	Literature dan observation	<ol style="list-style-type: none"> 1. The increasing number of SARS-CoV-2 transmission anxiety to the health workers and the needs of personal protection equipment, effective desinfectant procedure to prevent cross-transmission and infection 2. In developing countries, solid waste is threw at open area and the laystall is not organised properly. The scavengers do not wear proper self protection equipment ay be exposed by Covid-9 because they hunt recylce materials. It affects on natural boita, cultural algriculture, fishery, health of human and animals 3. VH2O2 disinfection strategy, UVGI and light liquid have been determined, but some requirement is needed to gain convince from the health workers to re-use protection equipments post treatment. 4. FDA already gave permission to use VH2O2 technology, under the otority of EUA, to re-process facial mask N95 which overcomes Covid-19 tranmission in USA. 5. The technology of re-processing is the use of hydrogen peroxide in a vapor state (VH2O2) for personal protection equipments tendance 6. Stryker STERIZONE VP4 Sterilizer, has been approved to re-process for N95 facial mask by FDA in accordance with EUA, using joint ozone and VH2O2. 7. Many countries recommend to use VH2O2 for N95 respirator deconstruction.
2	Xiang Zhao dan Fengqi You (2021)	Waste respirator processing system for public health protection and climate change mitigation under COVID-19 pandemic: Novel process design	State of US on the northeast, near New York metropolitan area, As New York, New Jersey, Pennsylvani	Descriptive Qualitative	Survey	<ol style="list-style-type: none"> 1. VH2O2 has been approved to decontaminate protection equipments under the control of UAE by tha FDA in USA to overcome the lack of stock in Covid-19 pandemic Amerika. 2. Some countries give permission to decontaminate and re-use of personal protection equipments. The decission is given to health institute manager.

Tabel 2. Study tabulation within the literature review

No	Author, Year of publication	Tittle of the journal	Population and Sample	Research Type	Data Collection	Important Found
		and energy, environmental, and techno-economic perspectives	a, Massachus etts, New Hampshire, Vermont, Rhode Island, And Connecticut.			
3	Piotr Nowakowski , Sandra Ku'snierz, Patrycja Sosna, Jakub Mauer and Dawid Maj (2020)	Disposal of Personal Protective Equipment during the COVID-19 Pandemic Is a Challenge for Waste Collection Companies and Society: A Case Study in Poland	Silesia, Polandia	Qualitative	Online interview and survey	<ol style="list-style-type: none"> 1. Local government follows the policy of the Ministry of Health and The Head of The General Cleanng Department about the collection, identification, and waste carriage, and preparation of campaign of the collection companies. However, it is hard to introduce new method for collecting the protection equipments of the collection companies because of some reasins. The most challenging is additional cost for additional waste collection. 2. The difference of waste management between the local government and the collection companies. 3. From the local government's point of view, it is easy to prepare all requirement for all candidates from the supply chain, but they are opposed to obey the rules of Public Health Service. 4. The survey result shows that collection companies found difficulties because of the additional cost in order to change the collection method or the schedule. Even, in several case, they need to change the route or the using particular medical waste transportation. 5. It is not easy to introduce particular method for collecting personal protection equipments.
4	Seung-Whee Rhee (2020)	Management of used personal protective equipment and wastes related to COVID-19 in	The research was carried out in South Korea	Qualitative	Literature dan observasi	<ol style="list-style-type: none"> 1. As a lesson about controlling infection , in South Korea has been determined some principals to manage virus infection and the waste. These principals are explained as the continue, transparation, and security. 2. Waste management process must follow some stages : 'Throw in the rubbish for medicak waste'; ' retention in a certain storage

Tabel 2. Study tabulation within the literature review

No	Author, Year of publication	Tittle of the journal	Population and Sample	Research Type	Data Collection	Important Found
		South Korea				<p>facility; 'Transportation for medical waste';' tendence with incineration; 'management. The process is determined by enviromental office and being checked by the government.</p> <ol style="list-style-type: none"> 3. Medical waste, such as facial mask, handsshove must be thrown separately, using certain container with the red 4. The goverment and collector must control the waste flow using advanved technology. 5. Strengthening the control system of collecting, transporting and managing
5	Jie Peng MM, Xunlian Wu, Rongli Wang MM, Cui Li MM, Qing Zhang BM, Daiqing Wei MD (2020)	Medical waste management practice during the 2019-2020 novel coronavirus pandemic: Experience in a general hospital	In a hospital at Wuhan, China	Qualitative	Survey and observation	<ol style="list-style-type: none"> 1. Manaing medical waste involves many departments, including government and individuals that need to cope with each other. 2. In the first period of epidemic, the multisectoral team and management is formed in the hospital. This structure unites and coordinate any training of Covid-19, supervision of safety management, material provision, and medical waste disposal. 3. Therefore, a storage facility is built to keep Covid-19 medical waste. 4. Dicposal companies must collect the waste from the storage facility without any unnecessary contact. Time and track collection of the medical wastemof Covid-19 is different than common medical waste, to reduce any leakage and harm risk at the time of transferring and to increase the effectiveness.
6	Syauki Isykapurnama, Darsih Sarasri, Hega 'Aisyah Mahardika, (2021)	Potensi Teknologi Pengolahan Berbasis Pirolysis dalam Penanganan Limbah Alat Pelindung Diri yang Menumpuk di Masa Pandemi Covid-19		Literature study	The source of this study is data secunder, including internet, research , proceeding, national and international journal	<ol style="list-style-type: none"> 1. Pyrolysis technology as a solution to overcome protection equipment waste in pandemic, whereas the material of the equipment is plastic. 2. The principle of pyrolysis technology is the conversion of plastic waste to become fuel, where the process could change the plastic as it was. 3. The increasing number of infectius waste is not supported by the rise of waste management facility. From 2.889 hospital in Indonesia, only 110 hospitals that have permitted incinerator facility.

-paration to do medical management that suits the guidance is easy.⁸

In other literature shows that South Korea has determined principles to manage virus infection and infectious waste. Those principles are consist of throw in the rubbish for medical waste, retention in a certain storage facility, transportation for medical waste, the tendency with incineration. The stage is proved effective because it is determined by the Environmental Department of Sut Korea and always gets attention from the local government.⁹

In Wuhan, at the first period of the pandemic has formed special multisectoral team and management structure to manage medical waste. The practice of medical waste management is conducted by differentiating infection waste and storage time. It is done to avoid new sources of infection. Thus, particular storage for Covid-19 medical waste is built separately. The disposal track involves temporary retention, collection, transportation, and centrally disposal.¹⁰

Research by Hantoko (2021) reports that other countries have their own rules and procedure for medical waste disposal from the hospital and the household.¹¹ Strict procedure and guidance of Covid-19 waste must be followed by caution to prevent virus infection. The waste of Covid-19 must be handled and managed using the national or international protocol. The process of managing involves handling and waste storage, collection and transportation, managing or disposal.

Challenge to manage solid medical waste in a pandemic era

Covid-19 has been existed for more than a year, with the different prevalence events in every country. Besides, Covid-19 is determined as the global health crisis as the effect to the environment. Any action to overcome Covid-19 also increases the medical waste's insignificant number.¹² In addition, any activity of the society has appeared new problem in medical waste. The use of protective equipment, such as facial mask, hand gloves, cleaners, and etc have

changed the perspective of the trend in waste.¹³

Solid medical waste is divided into nine criteria, as follows, infection waste, pathology waste, sharp object waste, pharmacy waste, radioactive waste, cytotoxic waste, pressed container waste, and high heavy metal waste. High enhancement of outworn protection equipment and wide distribution of solid medical waste from the hospital, healthcare facility, till home quarantine is found almost every day. It causes the healthcare facility facing overwhelmed, forcing them to do urgent care and disposal (for example, disposal in city waste incinerator, kiln, industrial stove) to upgrade the capacity.¹¹

According to research by Neil dan John (2021), the enhancement of medical waste is worried to have the potential of SARS-Cov-2 infection, moreover if disinfection has not been done effectively.⁴ In developing counties, solid medical waste is easy to find in open places and put inlay still without any management. Because of this improper disposal, it will affect natural biota and agriculture.

Another challenge also delivered by Piotr et al., (2020) in managing solid medical waste is a challenge to introduce a new method that relates to waste management, lack of collection companies and at the same time, the pile of medical waste keeps increasing and cannot be contained optimally. It was also strengthened by research in Indonesia about the volume of solid medical waste is not equal with the waste management facility, although the pyrolysis method is already conducted.¹⁴

Seung-Whee Rhee (2020) asserts that the role of policy instance is important to optimize solid waste management because the policy will run properly if all the component sources could contribute and do collaborate.⁹

Jie Peng MM, et al., (2020) also asserts that managing medical waste cannot be done individually, it must involve other departments, as the government, companies, and society.¹⁰

Conclusions

Effectivity in managing waste is needed, no matter what method is used. Sterilizer technology, as VH₂O₂ and Stryker STERIZONE VP4, and the development of waste respirators with pyrolysis process are considered as effective methods. The effectiveness of a method depends on the implementation of the process. Either effective or not, solid medical waste will affect the transition of SARS-Cov-2 infection. Various methods have been applied on the national or international stage, but this matter needs to adjust with the policies of the countries and the collaboration of the policymaker and the society.

Funding

None were received

Author Contribution

According to the contributor roles taxonomy (CRediT) author statement: HNA was responsible for conceptualizing, writing the original draft. HAI worked on the original writing and drafting methodology. SI literature search and article screening. GN writes, reviews and edits. EAW translator.

Ethics approval

Not applicable

References

1. World Health Organization. Coronavirus disease (Covid19) Weekly Epidemiological Update and Weekly Operational Update. Geneva: World Health Organization; 2021. Available from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>.
2. Sangkham S. Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. *Case Studies in Chemical and Environmental Engineering*. September 2020;2: 100052. doi: 10.1016/j.cscee.2020.100052.
3. Behera BC. Challenges in handling COVID-19 waste and its management mechanism: A Review. *Environmental Nanotechnology, Monitoring & Management*. May 2021;15:100432. doi: 10.1016/j.enmm.2021.100432.
4. Rowan, Neil J., and John G. Laffey. Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic—implications for efficacy, re-use and sustainable waste management. *Science of the Total Environment*. 2021; 752:142259.
5. Rowan, N. J., & Laffey, J. G. Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic—Implications for efficacy, re-use and sustainable waste management. *Science of the Total Environment*. 2020;142259.
6. Zhao, Xiang, and Fengqi You. "Waste respirator processing system for public health protection and climate change mitigation under COVID-19 pandemic: Novel process design and energy, environmental, and techno-economic perspectives." *Applied Energy*. 2021;283: 116129.
7. Dharmaraj, S., Ashokkumar, V., Pandiyan, R., Munawaroh, H. S. H., Chew, K. W., Chen, W. H., et al. Pyrolysis: An effective technique for degradation of COVID-19 medical wastes. *Chemosphere*. 2021;130092.
8. Nowakowski, P., Kuśnierz, S., Sosna, P., Mauer, J., & Maj, D. Disposal of Personal Protective Equipment during the COVID-19 Pandemic Is a Challenge for Waste Collection Companies and Society: A Case Study in Poland. *Resources*. 2020; 9(10):116.
9. Rhee, S. W. Management of used personal protective equipment and wastes related to COVID-19 in South Korea. *Waste Management & Research*. 2020; 38(8): 820-824.
10. Peng, J., Wu, X., Wang, R., Li, C., Zhang, Q., & Wei, D. Medical waste management practice during the 2019-2020 novel coronavirus pandemic: Experience in a general

- hospital. American journal of infection control. 2020; 48(8): 918-921.
11. Hantoko, D., Li, X., Pariatamby, A., Yoshikawa, K., Horttanainen, M., & Yan, M. Challenges and practices on waste management and disposal during COVID-19 pandemic. Journal of Environmental Management. 2021; 112140.
 12. Goswami, M., Pranjali J.G., Sunil N., Satya P. Challenges and actions to the environmental management of Bio-Medical Waste during COVID-19 pandemic in India. Journal Helion. 2021;6313.
 13. Tripathi, A., Vinay KT., Vivekanand V., Purnendu B., Surindra S. Challenges, opportunities and progress in solid waste management during COVID-19 pandemic. Journal Case Studies in Chemical and Environmental Engineering. 2020;02:100060.
 14. Isykapurnama, S., & Sarastri, D. Literature Review: Potensi Teknologi Pengolahan Limbah Berbasis Pirolisis dalam Penanganan Limbah Alat Pelindung Diri yang Menumpuk di Masa Pandemi Covid-19. Generics: Journal of Research in Pharmacy. 2021;1(1).
 15. Zhao, X., & You, F. Waste respirator processing system for public health protection and climate change mitigation under COVID-19 pandemic: Novel process design and energy, environmental, and techno-economic perspectives. Applied energy. 2021;283: 116129