Experiment on Decomposition of Disposable Mask Waste Using Acid Liquid

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Abstract

The COVID-19 pandemic has led to an increase in disposable mask usage, raising environmental concerns due to improper disposal. This research aims to investigate the decomposition of disposable mask waste, specifically duckbill masks, by immersing them in 32% HCl and 98% H2SO4 solutions. This research uses experimental research methods for processing mask waste using the method of immersion in 32% HCl solution and immersion in 98% H2SO4. Fifty grams of mask waste were soaked in 1000 ml of each acid solution for periods of 1, 2, 3, and 4 weeks, with four replications for each time period, and water used as a control. After soaking, the masks were dried and re-weighed to assess weight loss. The data were analyzed using T-tests and ANOVA with SPSS 26. Results showed that after 4 weeks, H2SO4 reduced mask mass by 26%, while HCl achieved a 22% reduction. In the first week, H2SO4 reduced the weight by 3 grams, increasing to a total reduction of 13 grams by the fourth week. Similarly, HCl reduced the mask weight by 2 grams in the first week, with a total reduction of 11 grams by the end of the experiment. The findings suggest that H2SO4 is more effective than HCl in degrading disposable mask waste, offering a potential solution for managing mask waste environmentally. For the local government, it is necessary to make efforts to socialize the community in order to broaden their knowledge regarding the management of disposable mask waste so that the volume of mask waste stockpiles can be reduced and can be more beneficial.

Keyword: Disposable Mask waste, Decomposition, HCL, H2SO4, Acid Liquid

INTRODUCTION

The COVID-19 pandemic has made masks an item that must be used when doing activities outside the home, on the one hand it helps people avoid viruses, on the other hand it is dangerous for the environment. If previously hospitals were the biggest contributors of infectious waste, now masks seem to be part of the daily waste produced by society. Masks have become a primary need during the COVID-19 pandemic (Matin et al., 2022). Single-use face masks are one of the most used PPE to prevent the transmission of the virus. However, mismanagement of such materials threatens the environment with a new form of plastic pollution. Researchers argue that it is necessary to develop and implement innovative ways to manage and recycle PPE in order to reduce their impacts on the environment (De-la-Torre et al., 2021).

If waste management does not work well, concerns arise that used masks that should be disposable will actually be reused by individuals for reuse or resale. Not to mention, another major problem is environmental pollution. The spread of COVID-19 is not only disrup the economic sector and healthy, but also annoying environmental cleanliness due to improvement

the amount of waste generated by society in Indonesia. Virus spread this also adds to the waste problem, especially medical waste (Wang et al., 2023).

Medical masks, which are also one of the wastes that have the potential to become infectious waste, can spread viruses through soil and water (Rinaldi et al., 2021). Besides having the potential to spread viruses, disposable medical mask waste can also pollute the environment, both land and water, because it contains microfibers which in the water break down into plastic microfiber fibers which can be toxic if ingested by marine biota (Saliu et al., 2021).

Using a mask is one way to prevent transmission of the COVID-19 virus. One type of mask used by the public is a disposable mask. The increase in the use of disposable masks during the pandemic occurred throughout the world, with estimates of daily mask use in several countries in Asia reaching 2.228.170.832 masks per day. The large number of masks used creates new problems, namely the increase in the amount of single-use mask waste (Lidiawati et al., 2022).

Disposable mask waste contains plastic fibers which take a long time to decompose in the environment. The basic material for making disposable masks is polypropylene (pp). Polypropylene is a petrochemical product made from propylene mononer olefins through addition polymerization to form polymers with long polymer molecules or chains. Accumulations of waste often contaminated with organic materials, microorganisms, and biological fluids can cause sanitation problems or even collapse an entire city's waste management system. The COVID-19 crisis has unleashed a plastic disaster, reversing the gains of a decade of activism against single-use plastics worldwide (Rivas et al., 2020). This waste can be reused, recycled, or separated in ways that reduce costs (Wormer et al., 2013).

The first objective of any waste policy should be to minimize the negative effects of the generation and management of waste on human health and the environment. Re-use and recycling of waste, although of high priority in the waste hierarchy, is not necessarily always the best treatment method. One way of processing medical waste is incineration using the combustion method with an effective temperature of 800°C. The advantages of this method are that it can reduce large volumes of waste, is a fast process and can interact with power plants. However, it is necessary to provide air pollution control considering that the exhaust gas emissions produced are quite dangerous for the environment.

One of the processes for processing disposable mask waste is by soaking in H_2SO_4 and HCl, HCl and H_2SO_4 is a strong acid that is clear, odorless, and very corrosive to all objects, processing disposable mask waste will compare the solution that reduces the mass of disposable

mask waste the most. Processing of disposable mask waste is carried out by soaking using HCl and H_2SO_4 solutions to determine the reduction in the mass of disposable mask waste.

METHODS

This study uses an experimental method to process disposable mask waste through soaking in 32% hydrochloric acid (HCl) and 98% sulfuric acid (H_2SO_4) solutions. Mask waste weighing 50 grams was soaked in each solution with variations in soaking time, then weighed again to see the mass decrease.

The research was conducted at the Environmental Health Laboratory of Universitas Muhammadiyah Surakarta from March to April 2024. The population consisted of all objects tested, with a sample of 32 taken using non-probability sampling technique. The dependent variable is the mass reduction of mask waste, while the independent variable is the soaking method (clean water, HCl, and H_2SO_4). The tools used include clean containers, scales, 16 plastic containers, claws, and trays for drying. The materials used were mask waste, clean water, 16 liters of 32% HCl liquid, and 16 liters of sulfuric acid.

The research stages began with the collection and weighing of 50 grams of mask waste, then soaking in the solution for 1 to 4 weeks. After soaking, the waste was dried in the sun to dry, then weighed again. The weighing data was used to analyze the effectiveness of each method. Observations were made during the process to record changes that occurred, with the aim of determining which method was more effective in decomposing disposable mask waste. Data analysis with bivariate analysis using the T-test and ANOVA test which data processing using SPSS version 26 software. This research has been approved by the Health Research Ethics Commission of Dr. Moewardi General Hospital with number 1.938/VII/HREC/2024.

RESULTS

Experimental Results of Disposable Mask Waste Processing With HCl

The weight of disposable mask waste is weighed at 50 grams each, every week the treatment is carried out 4 times with a weight of 50 grams before soaking, then the masks are placed in a glass container and then doused with 1000 ml of HCl solution carried out in the acid chamber in the environmental health laboratory. Then close it tightly and wait for the specified time. After soaking for 1 week, 2 weeks, 3 weeks, and 4 weeks, the mask was then removed and dried in the sun for 3 hours. After the mask was dry, the weight of the mask was weighed after soaking and the results were obtained as in the table below.

Table 1. Weight of mask waste before and after soaking in HCl solution

Intervention	Weight of Mask with Different Solution										Asymp.Sig
	Ctrl	HCl (g)				Ctrl	HCl (g)				
		P1	P2	P3	P4		P1	P2	P3	P4	
	Before					After					
One week	50	50	50	50	50	50	48	48	48	48	0.46
Two week	50	50	50	50	50	50	47	47	47	47	0.46
Three week	50	50	50	50	50	50	41	41	41	41	0.46
Four week	50	50	50	50	50	50	39	39	39	39	0.46

Based on the results of the analysis of treatment using HCL, it is known that the weight of the waste before treatment was 50 grams. The results obtained from four treatments using HCL in the first week were a decrease in waste weight by 2 grams to 48 grams. This was found in all four experiments in treatment using HCL. Thus, it can be understood that in the first week there was a decrease in the weight of mask waste by 4% of the initial waste weight. Then in the second week there was a decrease in waste weight in the treatment using HCL by 3 grams to 47 grams. Thus, in the second week, the reduction in waste weight was 6% of the initial waste weight.

A significant reduction in waste weight in the treatment using HCL was only found in the third week. That is, there was a decrease of 9 grams to 41 grams. Thus, in the third week, there was a decrease in the weight of mask waste by 18% from the initial waste weight. Finally, the reduction in waste weight in the fourth week was 11 grams to 39 grams. Based on the results obtained, a T-Test was carried out using SPSS. The results showed that there was a decrease in the mass of disposable mask waste after soaking in HCL solution every week.

Experimental Results of Disposable Mask Waste Processing With H_2SO_4

The weight of disposable mask waste is weighed at 50 grams each, every week the treatment is carried out 4 times with a weight of 50 grams before soaking, then the masks are placed in a glass container and then doused with 1000 ml of H_2SO_4 solution carried out in the acid chamber in the environmental health laboratory. Then close it tightly and wait for the specified time. After soaking for 1 week, 2 weeks, 3 weeks, and 4 weeks, the mask was then removed and dried in the sun for 3 hours. After the mask was dry, the weight of the mask was weighed after soaking and the results were obtained as in the table below.

Table 2. Weight of mask waste before and after soaking in H_2SO_4 solution

Intervention	Weight of Mask with Different Solution										Asymp. Sig
	Ctrl	H_2SO_4 (g)				Ctrl	H_2SO_4 (g)				
		P1	P2	P3	P4		P1	P2	P3	P4	
	Before					After					
One week	50	50	50	50	50	50	47	47	47	47	0.46
Two week	50	50	50	50	50	50	46	46	46	46	0.46
Three week	50	50	50	50	50	50	40	40	40	40	0.46
Four week	50	50	50	50	50	50	37	37	37	37	0.46

In the treatment using H_2SO_4, it was discovered that the initial weight of the mask waste was 50 grams. The results of the treatment obtained in the first week using H_2SO_4 were a reduction in the weight of mask waste by 3 grams to 47 grams. Thus, in the third week, there was a decrease in the weight of mask waste by 6% from the initial waste weight. Then in the second week, the waste weight decreased by 4 gram to 46 grams. Thus, the reduction in waste weight that occurred in the third week was 8% of the initial waste weight.

A significant reduction in the weight of mask waste using H_2SO_4 treatment was also found in the third week, where there was a reduction in waste weight of 10 grams to 40 grams. Thus, there was a decrease of 20% of the initial waste weight in the third week. Finally, in the fourth week, there was a decrease in waste weight by 13 grams to 37 grams. Then, for the T-Test, it was found that there was a decrease in the mass of disposable mask waste after soaking in the H_2SO_4 solution. Based on the results obtained, a T-Test was carried out using SPSS. The results showed that there was a decrease in the mass of disposable mask waste after soaking in H_2SO_4 solution every week.

Table 3. Weight Decrease of mask waste with HCl Solution

	Week-1	Week-2	Week-3	Week-4
Weight Decrease with HCl Solution (gr)	2	3	9	11
	2	3	9	11
	2	3	9	11
	2	3	9	11
Asymp. Sig	008	008	008	008

Then, the results of the data on the reduction in the mass of waste masks every week were carried out by an Anova test and it was found that there was a difference in the reduction in the mass of waste from disposable masks soaked in HCl solution between the first week, second week, third week and fourth week.

Table 4. Weight Decrease of mask waste with H_2SO_4 Solution

	Week-1	Week-2	Week-3	Week-4
Weight Decrease with H_2SO_4 Solution (gr)	3	4	10	13
	3	4	10	13
	3	4	10	13
	3	4	10	13
Asymp. Sig	008	008	008	008

Then, the results of the data on the reduction in the mass of waste masks every week were carried out by an Anova test and it was found that there was a difference in the reduction in the mass of waste from disposable masks soaked in H_2SO_4 solution between the first week, second week, third week and fourth week.

T-Test Weight Decrease (g)

Intervention	HCl	H_2SO_4	Asymp. Sig
Week1st - Repetition 1st	2	3	<0,0001
Week1st - Repetition 2nd	2	3	<0,0001
Week1st - Repetition 3rd	2	3	<0,0001
Week1st- Repetition 4th	2	3	<0,0001
Week 2nd - Repetition 1st	3	4	<0,0001
Week 2nd - Repetition 2nd	3	4	<0,0001
Week 2nd - Repetition 3rd	3	4	<0,0001
Week 2nd - Repetition 4th	3	4	<0,0001
Week 3rd - Repetition 1st	9	10	<0,0001
Week 3rd - Repetition 2nd	9	10	<0,0001
Week 3rd - Repetition 3rd	9	10	<0,0001
Week 3rd - Repetition 4th	9	10	<0,0001
Week 4th - Repetition 1st	11	13	<0,0001
Week 4th - Repetition 2nd	11	13	<0,0001
Week 4th - Repetition 3rd	11	13	<0,0001
Week 4th - Repetition 4th	11	13	<0,0001

And to determine the difference in mass reduction of disposable mask waste, a T-Test was carried out to reduce the mass of mask waste soaked in HCl solution and H_2SO_4 solution for four weeks with four repetitions. And the results obtained were that there was a difference in mass reduction between immersion using an HCl solution and an H_2SO_4 solution.

DISCUSSION

The Covid-19 pandemic has changed the dynamics of global waste generation so it needs special attention. As a consequence of the pandemic, sources of waste generation and waste volumes have changed drastically, but the causes of environmental pollution from various sectors such as transportation, aviation and industry have decreased (Han et al., 2021).

The analysis revealed that the initial weight of mask waste was 50 grams for both the HCl and H2SO4 treatments. In the first week, HCl reduced the waste by 2 grams (4%), and by 3 grams (6%) in the second week. A significant reduction occurred in the third week, with a decrease of 9 grams (18%), and by 11 grams in the fourth week, leaving a final weight of 39 grams (22%).

In the H2SO4 treatment, the waste decreased by 3 grams (6%) in the first week and by 4 grams (8%) in the second week. A major reduction occurred in the third week, with a drop of 10 grams (20%), and by 13 grams in the fourth week, resulting in a final weight of 37 grams (26%). These findings suggest that H2SO4 is more effective than HCl in reducing mask waste, achieving a 26% reduction compared to HCl's 22%. This study offers preliminary evidence that H2SO4 is more effective for mask waste reduction than HCl.

The T-Test results showed a weekly reduction in the mass of disposable mask waste soaked in HCl and H2SO4 solutions. Further ANOVA tests showed significant differences in mass reduction in the first, second, third, and fourth weeks for the HCl and H2SO4 treatments.

To determine the difference in mass reduction of disposable mask waste, a T-Test was conducted comparing the reduction in mass after soaking in HCl and H2SO4 solutions for four weeks, with four repetitions. The results showed a significant difference in mass reduction between the two treatments. Using a Paired Sample T-test, a significance value of 0.01 ($p>0.05$) was obtained, indicating a significant relationship between the immersion process and the reduction of disposable mask waste for both HCl and H2SO4 treatments. These results are in accordance with the literature which states that HCl and H_2SO_4 solutions are strong acid compounds that are stable, easily soluble or can dissociate in water at all ratios, can act as dehydrating agents, are strong oxidizers and have more active sites that can react incorrectly. One material in disposable mask waste is polypropylene (Mukhlis et al., 2021).

This result is in accordance with the literature which states that polypropylene has high resistance to chemicals, soluble in high molecular weight aliphatic and aromatic hydrocarbons and at high temperatures. Polypropylene can also be oxidized by oxidizers such as concentrated H2SO4 and HNO3. Polypropylene can be oxidized because in the chemical structure of polypropylene there are primary, secondary, and tertiary C atoms. H atoms bound to tertiary C atoms in the polypropylene molecular chain are less stable than those bound to primary and secondary C atoms so that soaking with H2SO4 can reduce the weight of the mask waste. (Wagiswari et al., 2016).

The use of HCl as an activator will affect the absorption because the HCl can react with Fe_2O_3, Al_2O_3, CaO, and MgO in the adsorbent so that the reaction can dissolve in a solution. This results in the opening of closed pores to increase the diameter of the adsorbent surface so that soaking with HCl can reduce the weight of the mask waste (Widodo *et al.*., 2020).

Disposable mask waste contains plastic fibers that take a long time to decompose in the environment. The basic material in the manufacture of disposable masks is Polypropylene (PP). Polypropylene is a downstream petrochemical product derived from propylene monomer olefins through addition polymerization to form polymers with long molecules or polymer chains. Polypropylene is currently one type of plastic used in various industries such as packaging, construction, automotive, and sports. In addition, it is also the material for making disposable masks. Polypropylene is also a very cheap and flexible polymer to mold so it is widely used in various needs. However, unlike other plastic materials, Polypropylene takes a long time to decompose in the environment (Rebia *et al.*., 2022).

Plastic waste can be utilized as an adsorbent using the adsorption method to treat wastewater before being discharged into water bodies because it contains carbon elements,

such as polyethylene, polypropylene or polyvinyl chloride plastics (Stephani & Hendrasarie, 2021). One of the treatment processes for disposable mask waste is H2SO4 and HCl soaking.

Research Deviany et al., (2023), showed that the use of HCl was effective in reducing the mass of mask waste. However, the HCl extract used in the study was 25%. Then in research by Kadasih et al., (2023), shows the effectiveness of using H2SO4 as a catalyst to reduce the mass of mask waste.

CONCLUSIONS

Based on the results and discussion of the research that has been carried out, it is concluded that the processing of disposable mask waste is more effective by soaking in H2SO4 solution to reduce the mass of waste compared to HCl, and the soaking process is directly proportional to the amount of reduction in the mass of waste masks, in the sense that the longer the process takes. Soaking means the greater the reduction in the mass of mask waste. There has not been much research comparing the two substances to reduce the mass of mask waste. Thus, the following research can be an initial reference which shows that the use of H2SO4 reduces the waste mass of disposable masks more than HCl.

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