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Potential Impact of Disposable Mask Garbage Pollution in Cinere District

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Abstract: At present, disposable masks have become a necessity and habit for the general public. This causes an increase in the volume of single-use mask waste generation. If disposable mask waste is not managed properly and correctly it can harm living things such as fauna and contains micro plastics which have the potential to be a source of pollution in the environment. This study aims to analyze the potential impact of household-scale disposable mask waste pollution in Cinere District. The method used in this research is statistics and literature study. The results showed that the average use of disposable face masks in Cinere District was 2 pieces/day with a weight of 3.54 grams and it was estimated that the people of Cinere District produced 76,494 disposable masks waste/day with an extrapolation of the potential impact of micro plastic pollution reaching 67.31 billion/day which will be released into the environment. This will be a heavy burden on the environment, therefore good cooperation is needed between the community and the government in managing disposable mask waste on a household scale in order to reduce and prevent pollution of disposable mask waste in the environment.

Keywords: Disposable mask; Garbage pollution; Potential impact; Single-use mask waste

Introduction

The use of disposable masks has become a necessity and habit for most people since the outbreak of the COVID-19 outbreak. Disposable masks are considered effective in preventing the transmission of various viruses including COVID-19, according to the Big Indonesian Dictionary, masks are a device that covers the mouth and nose which functions as a protector from direct transmission of infectious agents and dust. Disposable masks can provide effective protection of 85 to 99% to prevent transmission of infectious diseases (Dwirusman, 2020). An in vitro model study tested the effect of disposable masks as aerosol filters on mannequins. The test results show that wearing a mask on a mannequin can reduce the amount of aerosols so that it can be said that masks are a physical barrier and are more effective when used on someone who emits droplets. Using a mask correctly is a method to prevent the evaporation of droplets into aerosol particles that are 3-5 times smaller in size (Long et al., 2020; Huang et al., 2020). If everyone uses a mask to reduce the risk of transmission to others, more people will be protected. However, improper disposal and management creates a very large waste footprint in the environment.

Disposable masks generally consist of three layers, namely the outer layer (spun-bond polypropylene) made of non-absorbent material as protection from splashing liquids, the middle layer (melt-blow polypropylene) which functions to prevent droplets and aerosols through electrostatic effects, and the inner layer (spun-bond polypropylene) made of an absorbent material such as cotton to absorb steam (Figure 2) (Prata et al., 2020; Fadare & Okoffo, 2020; Xu & Ren, 2021). Disposable masks are primarily made of polypropylene and high-density polyethylene, and may contain other polymeric materials such as polyester, polyurethane, polystyrene and polyacrylonitrile (Fitria et al., 2022). Polypropylene with a density of 0.946 g/cm^3 is the main

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material that is widely used in disposable masks. Polypropylene can be fragmented through photochemical and mechanical processes under the influence of heat, wind, ultraviolet radiation, ocean currents, and eventually form microplastics with a size < 5 mm which can last hundreds of years in the environment (Sun et al., 2021).

Various studies state that microplastic pollution is a big problem because of its huge impact on the environment. Microplastics contain toxic chemicals such as phthalates, organotins, nonylphenols, polybrominated biphenyl ethers, and triclosan. These toxic chemicals can be released into the environment in the degradation process of plastic polymers, which can harm flora and fauna (Aragaw, 2020). Discarded microplastic waste takes up to hundreds of years to decompose, and dumping it into the natural habitat of animals on land and in the sea can cause animals to eat it which can cause death (Saadat et al., 2020). It can also affect the food chain resulting in animal scarcity and food scarcity. In the tourism industry, coastal areas that are polluted with plastic can reduce aesthetic value so that it can reduce the income of local people and foreign exchange. In addition, the generation of plastics and microplastics in the environment will affect global warming due to carbon emissions and affect climate change (Aragaw, 2020).

The increase in the use of disposable face masks is not only happening in health facilities but also in the household environment which should be of particular concern. Therefore, this study aims to analyze the potential impact of household-scale disposable mask waste pollution in Cinere District. The selection of Cinere District, Depok, West Java in this study was based on data on the distribution of COVID-19 cases in January 2022 where Depok City was recorded as the area with the highest COVID-19 cases in West Java, namely active cases reaching 11,324, and total positive confirmations reaching 111,499 cases. Depok City recorded the highest number of daily additional cases during the COVID-19 pandemic, reaching 2,094 cases with the highest number of active confirmed cases of COVID-19 being recorded by Cinere District (Satuan Tugas Penanganan COVID-19, 2021).

Method

Study Area

Cinere District is located in the Depok City area which is astronomically located at coordinates 6°19'00''-6° 28'00'' south latitude and 106°43'00''-106°55'00'' east longitude with an area area of Cinere District 1,056 Ha. Administratively, Cinere District with regional boundaries as follows:
North: Cilandak District, South Jakarta
West: Ciputat District, South Tangerang City
South: Limo District, Depok City
East: Pasar Minggu District, South Jakarta.

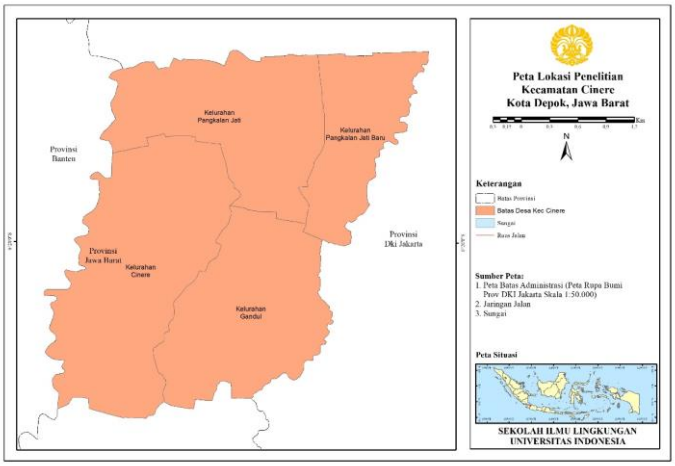

Figure 1. Map of research locations

The Cinere District is divided into 4 subdistricts, namely Cinere Subdistrict with an area of 3.717 km² consisting of 12 RW areas and 95 RT areas; Gandul Village with an area of 2.643 km² consisting of 10 RW areas and 46 RT areas; Pangkalan Jati Village with an area of 2.659 km² consisting of 7 RW areas and 42 RT areas; and Pangkalan Jati Baru Village with an area of 1.533 km² with an area consisting of 6 RW areas and 34 RT areas.

Population and Sample

The population in this study was household-scale disposable mask waste in the Cinere District, Depok, West Java. Based on the Central Bureau of Statistics for the City of Depok, the population of people in Cinere District is 84,767 people (BPS, 2023). Sampling of disposable mask waste generation is carried out based on SNI 19-3964-1994, where in the implementation of waste generation sampling is carried out at random strata with the following number.
1) The number of sample souls and heads of households (KK) can be calculated based on the formula below.

$$S = C_d\sqrt{P_S} \quad (1)$$

Description:
S : Number of Samples (Soul)
C_d : Housing Coefficient
P_S : Population (Soul)

Based on this formula, the number of samples is 180 people. With the following details:

$$S = 1\sqrt{84{,}767} = 291 \text{ soul}$$

2) To find out the number of household heads, the following formula can be used:

$$K = \frac{S}{N} \quad (2)$$

Description:
K : Number of Samples (KK)
S : Number of Samples (Soul)
N : Number of Souls per Family = 5

By entering the number of samples previously obtained, the sampling of disposable mask waste from the head of the family to be taken is:

$$S = \frac{291}{5} = 59 \text{ KK}$$

Methods for Analysis of Potential Pollution Impacts in Disposable Masks

The following calculation formula can be used to determine the amount of mask waste generated per person per day:

$$\text{Garbage generation} = \frac{m}{N} \quad (3)$$

Description:
m : Mask waste weight (g)
N : Number of soul samples (people)

The results obtained from data on the generation of disposable mask waste within 8 days of the Cinere District community, then an analysis of the potential impact of pollution that will be caused is based on previous literature studies. The equation used to calculate the extrapolation of the potential impact of microplastic pollution is as follows:

$$\text{Potential Pollution Impacts} = N \times n \quad (4)$$

Description:
N : Total Waste Generation
n : Total microplastic content

Result and Discussion

The following is the number of disposable masks used by people from households in one day based on the number of family members.

Table 1. Total Use of Disposable Face Masks in a Day by Households Based on Number of Family Members

Number of Mask Users/Family (people)	n	%	Average Number of Masks/person	Mask Weight Average (gram)
1	3	5.09	1.67	2.27
2	29	49.15	2.48	4.02
3	19	32.20	1.95	3.81
4	8	13.56	1.00	1.68
Total	59	100	2.07	3.54

Table 1 shows that the number of disposable masks used by the community for each family is different. Based on the results, the average use of disposable masks per person is 2.07 ≈ 2 pieces/day with an average weight of 1 mask of 3.54 grams. In calculating the estimated daily use of disposable masks in the general population, households in Cinere District and in Indonesia can use the following equation (Sangkham, 2020).

$$D_{FM} = P \times U_P \times F_{MAR} \times \left(\frac{F_{MGP}}{10{,}000}\right) \quad (5)$$

Description:
D_{FM} : Daily use of disposable masks (piece/day)
P : Population
U_P : Urban population (%)
F_{MAR}: Acceptance rate of disposable masks (80%)
F_{MGP}: Assumption that each person in the general population uses two single-use masks per day (based on research results)

Based on the equation above, it is estimated that disposable mask waste for households in Cinere District with a population of 84,767 people (BPS, 2023) and using the urban population percentage of 56.4% (Worldometer, 2023; BPS, 2023).

$$D_{FM} = 84{,}767 \times 56.4 \times 80 \times \left(\frac{2}{10{,}000}\right)$$
$$= 76{,}494 \text{ piece/ day}$$

Meanwhile, to calculate the estimate of disposable mask waste for households in Indonesia with a population of 273,753,191 (World Bank, 2023) and percentage of urban population 56.4% (Worldometer, 2023) are as follows:

$$D_{FM} = 273{,}753{,}191 \times 56.4 \times 80 \times \left(\frac{2}{10{,}000}\right)$$
$$= 247{,}034{,}880 \text{ piece/day}$$

The results of calculating the use of mask waste show that it is estimated that households in Cinere District amount to 76,494 pieces/day and in Indonesia produce disposable mask waste of 247,034,880 pieces/day. These results are in accordance with research Benson et al. (2021) that Indonesia is estimated to produce between 101-500 million disposable mask waste/day, which means that it is included in the 2nd class of the largest disposable mask waste disposal in the world. This becomes a very big burden on the environment if it is not managed properly and appropriately.

Polypropylene is the main material used to produce disposable masks (Selvaranjan et al., 2021). This is in accordance with the observations made by Rebia et al. (2022), functional groups of three-layer mask waste were confirmed and analyzed using a Nicolet™ iS50 Fourier Transform Infra–Red Spectroscopy (FTIR) Spectrometer. Based on the results of the functional group analysis, the outer (L), middle (T), and inner (D) layer masks (Figure 2) are characterized by the typical absorption of polypropylene. All samples showed the presence of wave numbers 2,948 cm^{-1}, 2,916 cm^{-1}, 2,866 cm^{-1}, and 2,837 cm^{-1} indicating the presence of a CH group, which was supported by a peak of 1,375 cm^{-1} indicating the presence of a CH_3 group (Figure 3). Based on the polypropylene spectrum reference, it shows the presence of methyl groups (-CH3) located at 2,970 cm^{-1} and 2,910 cm^{-1}, methylene groups (-CH2-) located at 2,870 cm^{-1}, 2,840 cm^{-1}, and 1,460 cm^{-1}, and minor peak (-CH3) at 1,370 cm^{-1} (Barbeş et al., 2014).

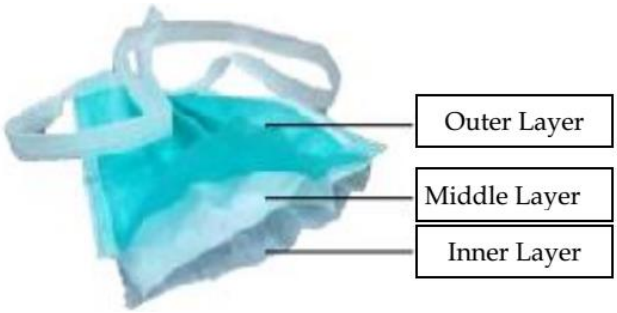

Figure 2. Layer structure in disposable masks (Handika et al., 2018)

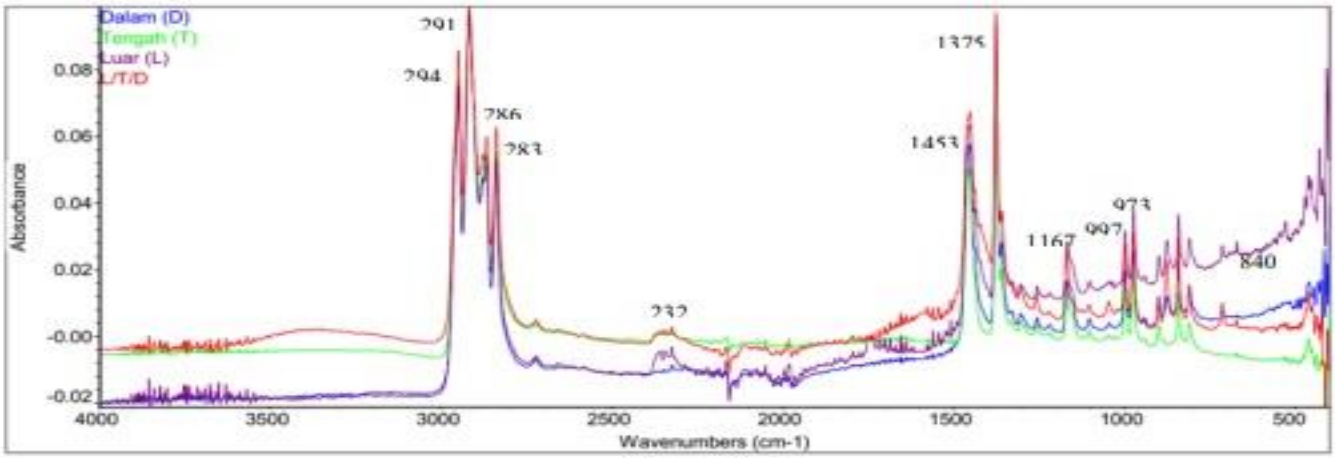

Figure 3. FTIR results on functional group analysis of disposable mask waste layers (Rebia et al., 2022)

Polypropylene is a vinyl polymer in which each carbon atom is attached to a methyl group (-CH3) (Figure 4). Polypropylene is a type of plastic that is often used in various industries because it is very cheap, has a low density that makes it easy to print, and has excellent chemical resistance (Hisham, 2016).

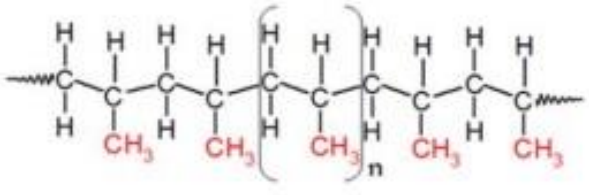

Figure 4. Chemical structure of polypropylene (Hisham, 2016)

Apart from polypropylene, disposable masks can also be made from other polymers such as polystyrene, polycarbonate, polyethylene and polyester (Abayomi et al., 2017; Abbasi et al., 2020; Li et al., 2020). The thermoplastic polymer fraction from the plastic content can break down into smaller particles or are called microplastics, this can occur due to several factors such as mechanical stress, agitation, exposure to UV light (Kutralam-Muniasamy et al., 2022), high temperature, hydrophobic, and changes in pH (Khoironi et al., 2020) which will slowly break down the carbon molecules in plastic or disposable mask waste (Armentrout, 2021). Polypropylene is difficult to degrade because it is very resistant, hydrophobic so that it prevents water from

decomposing molecules, high molecular weight and high surface roughness so that most of the polypropylene remains in the environment in the form of microplastics (Jiang, 2018) and takes more than 450 years to decompose in the environment (Mayers, 2021).

Based on the results of research that has been conducted by Sun et al. (2021) showed that a single-use mask weighing 3-4 grams can release at least 0.88 million microplastics. This is in accordance with the results of this study that the weight of household disposable face mask waste in Cinere District is 3.54 grams, so it can be calculated by extrapolating the potential impact of microplastic pollution from household scale disposable mask waste in Cinere District reaching 67.31 billion/day and in Indonesia it reaches 217.39 trillion/day of microplastics that will be released into the environment. This is a very large number that will burden the environment and will affect all living things, not only now, but even for hundreds of years to come.

Standards for handling and managing disposable mask waste in Indonesia refer to circular letter no. SE/MENLHK/PSLB3/3/2021 concerning Management of Infectious Waste (B3 Waste) and Household Waste from Handling COVID-19 (KLHK, 2021). Based on these guidelines, disposable mask waste is collected from the community, then disinfected by soaking the mask in a solution of disinfectant, chlorine or bleach. After that, change the shape of the mask by cutting it or destroying it so it won't be reused, and finally throwing it in the domestic trash with a tight plastic wrap. In accordance with the circular of the Minister of Environment and Forestry, the public can dispose of the mask waste in the trash or a special drop box for masks in public spaces that have been provided by the government. The implementation of disposable mask waste management can be optimal by bringing together the same perception between the government and the community. Communities must jointly participate in waste management. The hope for solid cooperation between communities is aimed at making solving environmental problems more easily realized.

Conclusion

The average use of disposable masks per person in Cinere District is 2 pieces/day with an average mask weight of 3.54 grams, so it can be estimated that households in Cinere District produce disposable mask waste of 76,494 pieces/day with extrapolation the potential impact of microplastic pollution reaches 67.31 billion/day which will be released into the environment. Outreach and education to the whole community and the need for good cooperation between the government, the community and relevant stakeholders in the management of household-scale disposable mask waste in order to achieve a common goal of preventing and reducing the potential impact of disposable mask waste pollution on the environment.

Author Contributions

Khairun Nisa conceptualized the research idea, designed of methodology, management and coordination responsibility, analyzed data, conducted a research and investigation process; Dwi Nowo Martono and Haruki Agustina conducted literature review and provided critical feedback on the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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