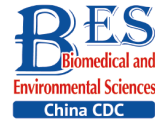


**Letter to the Editor****The Impact of the COVID-19 Pandemic on Urban Litter\***

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The effect of the COVID-19 pandemic on the composition and quantity of municipal solid waste has become a serious environmental concern<sup>[1]</sup>. For example, the change in the quantity of medical waste has been one of the definitive consequences of the pandemic. In the pre-pandemic period, according to a United Nations report<sup>[2]</sup>, the average generation of medical waste was 0.5 kg/bed per day, whereas reports during the pandemic showed that medical waste generation was 3.5 kg/bed per day<sup>[2]</sup>. Furthermore, an increase in some municipal solid waste compounds was observed as a result of the pandemic. For example, it is estimated that plastic waste increased by 20% during the pandemic and post-pandemic periods. This increase is due to the increase in plastic consumption for personal protective equipment and online shopping<sup>[2]</sup>. Increasing the production of plastic waste, even in the post-pandemic era, must be managed by social responsibility, corporate action, and government policy<sup>[3]</sup>.

However, the pandemic did not always lead to an increase in municipal solid waste. The changes in waste generation were different depending on geographical and sociological characteristics. During the pandemic, municipal solid waste generation in Shanghai, China, decreased by 23%, but in Singapore it increased by 3%<sup>[4]</sup>. Furthermore, in tourist cities during the pandemic, especially in the first months, the quantity of municipal solid waste decreased by 25%, 28%, and 17% in Barcelona, Milan, and Macau Special Administrative Region, China, respectively<sup>[2]</sup>. The COVID-19 pandemic has caused the emergence of new municipal solid waste components, of which

face masks are the most important. During the pandemic, 4,214, 310, 558, 122, and 309 tons/day of face mask waste were generated in China, Turkey, Japan, Malaysia, and Iran, respectively<sup>[5]</sup>.

Litter is waste that has not been properly disposed of in trash bins by citizens<sup>[6]</sup>. This behavior causes waste to be scattered across many urban and public environments<sup>[7]</sup>. Litter can have serious health and environmental consequences and leads to unfavorable landscapes. It includes various types of municipal solid waste, of which plastic and paper are the most common. Some types of litter, such as cigarette butts, have proven toxic effects. The leakage of various pollutants from cigarette butts, such as heavy metals and nicotine, has toxic effects on organisms and pollutes soil and water resources. For this reason, a special index has been used to assess this type of litter<sup>[7]</sup>.

The impact of the COVID-19 pandemic on urban litter was investigated by studying the density of COVID-19 related litter in Yasuj city, Iran. The streets were observed in the evening. Litter items, such as face masks, gloves, face shields, and alcohol-based solution bottles, were counted as COVID-19 related litter, but, due to the effect of environmental conditions on the weight and volume of litter, only their numbers were considered. Seven streets and two parks were studied (S1-S7 and P1-P2, respectively) and the density of COVID-19 related litter was measured once a week for six months during the pandemic.

The density of COVID-19 related litter compared to other litter is shown in Table 1. Litter density was highest in S7 (0.054), whereas it was lowest in P2

doi: 10.3967/bes2022.121

\*The financial support of the Yasuj University of Medical Sciences, Yasuj, Iran [Grant number: 4010053].

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(0.011). However, the density of the COVID-19 related litter was not proportional to the number of other litter items in the studied areas. The maximum and minimum COVID-19 related litter densities were observed in P1 and S6, which were 0.0078 item/m<sup>2</sup> and 0.0010 item/m<sup>2</sup>, respectively. The ratio of COVID-19 related litter to the total litter was not the same in different urban areas. On average, COVID-19 related litter constituted 13.19% of the total urban litter and was highest in P2 and lowest in S7 at 57.39% and 0.64%, respectively.

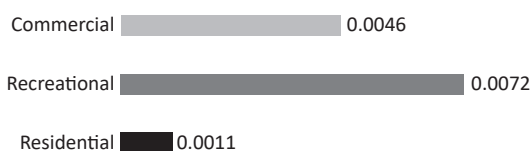
The results indicate that litter density shows spatial variation. The most important reason for the spatial variation in litter density is land use<sup>[7]</sup>. The population density is not the same in different land use areas. For example, the higher population density in commercial areas means that the probability of waste littering is greater than in residential areas<sup>[6]</sup>. In this study, the density of all litter types in S2 was 4.65 times more than in S5. This variation in COVID-19 related litter was almost the same as the variation for all litter types because the density of COVID-19 related litter in S2 was 4 times more than in S5. Furthermore, the litter density was lower in recreational land use areas than in commercial and residential areas. These results are consistent with a study on litter densities in other Iranian cities<sup>[6]</sup>. For example, the litter density in P2 (97%) was lower than the litter density in S7. However, the density of COVID-19 related litter in recreational areas was higher than the density of COVID-19 related litter in residential and commercial

areas. For example, the density of COVID-19 related litter in P1 was about 2.2 times greater than in S7. These conditions meant that the ratio of COVID-19 related litter to the total litter in recreational areas was much higher than in other areas. In P2, the ratio of COVID-19 related litter to the total litter was 57.39%, whereas this ratio was 1.14% in S4. The average density of total litter across different land uses and the ratio of COVID-19 related litter to total litter are shown in Figure 1 and Table 2, respectively.

The COVID-19 pandemic has affected the quantity and composition of litter in the urban environment in two ways. The decrease in the presence of people in public environments due to the fear of virus transmission and restrictions related to the pandemic, such as quarantine, are the first impacts of the pandemic on the density and composition of urban litter. These conditions will reduce litter densities in the urban environment and improve indexes, such as the clean environment index and environmental status<sup>[6]</sup>. These conditions were especially observed in recreational areas. Therefore, reduced litter densities in the urban environment due to the decrease in the population in commercial and recreational areas can be seen as a positive environmental consequence of the pandemic. However, the other impact of the pandemic on litter is the emergence of new types of litter, which is a negative environmental consequence of the pandemic. Some of citizens use personal protective equipment, such as face masks and gloves, on a daily basis. Unfortunately, during

**Table 1.** Litter quantities in the studied areas (item/m<sup>2</sup>)

Location	Land use	COVID-19 related litter	Other litter	Total litter	Ratio of COVID-19 related litter (%)
S1	Residential	0.0012	0.1482	0.1494	0.80
S2	Commercial	0.0044	0.5247	0.5291	0.83
S3	Commercial	0.0049	0.6751	0.6800	0.72
S4	Commercial	0.0057	0.4931	0.4988	1.14
S5	Residential	0.0011	0.1125	0.1136	0.96
S6	Residential	0.0010	0.1091	0.1101	0.90
S7	Commercial	0.0035	0.5367	0.5402	0.64
P1	Recreational	0.0078	0.0063	0.0141	55.31
P2	Recreational	0.0066	0.0049	0.0115	57.39



**Figure 1.** Density of COVID-19 related litter for each land use (number/m<sup>2</sup>).

**Table 2.** Litter quantity data for each land use (item/m<sup>2</sup>)

Land use	COVID-19 related litter	Other litter	Total litter	Ratio of COVID-19 related litter to total litter (%)
Residential	0.0011	0.123	0.124	0.89
Commercial	0.0046	0.557	0.562	0.83
Recreational	0.0072	0.0056	0.0128	56.35

the pandemic, some of this equipment littered the urban environment, especially parks and recreational areas. This effect can be recognized in the density and composition of litter in P1 and P2. These two recreational locations had the lowest litter densities compared to other studied locations, but the ratio of COVID-19 related litter, such as face masks and gloves, was higher than in the other studied locations.

Although the COVID-19 pandemic has had important effects on the density and composition of litter in urban environments, some other factors also affect the amount of pollution in cities. For example, the frequency and quality of cleanups in different parts of the city has an important effect on litter density<sup>[8]</sup>. The quality of the cleanups was the same in all the studied locations. Cleanup was done daily by the municipality, but the frequency of the cleanups in recreational areas, such as P1 and P2, was higher than in other locations. Therefore, the litter density in these places was less than in other locations. Although the lack of a sufficient number of trash bins is an important factor that leads to a high density of litter in places such as beaches, there was an appropriate number of trash bins in the studied urban areas, which suggested that littering, especially COVID-19 related litter, was caused by insufficient awareness of the negative consequences of litter and the lack of anti-littering laws<sup>[6,8]</sup>.

The COVID-19 pandemic has led to the emergence of new litter types in the urban environment that contain potentially infectious waste<sup>[9]</sup>. According to health protocols, the storage and collection of COVID-19 related waste should be done separately and in special bags. Littering caused by these wastes in urban environments increases the risk of virus transmission from the solid waste, especially for cleaning system staff. Therefore, one of the effects of the pandemic in the urban environment is the increase in the potential for disease transmission through potentially infectious litter, which represented an average of 13% of all litter in this study. Another important consequence of the pandemic is the increase in sources of pollutants, such as microplastics, in the environment. Litters such as face masks and gloves are made of plastic and their degradation, especially in coastal cities where these litter types could accumulate in water bodies, represents a potential new source of microplastics<sup>[10]</sup>. When considering the effects of the COVID-19 pandemic on the composition and density of litter in the urban

environment, the following are suggested for the management of COVID-19 related litter:

1. Preventing the littering of COVID-19 related litter by increasing citizen awareness of the health and environmental consequences of this waste.
2. Mitigation of COVID-19 related litter in the urban environment by increasing the numbers of general trash bins and special trash bins for potentially infectious waste in public environments.
3. Removal of COVID-19 related litter by increasing the efficiency of the cleanup system.

*Competing Interests* The authors of this article declare that they have no conflict of interests.

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Received: June 11, 2022;

Accepted: August 31, 2022

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