Available Online at https://www.nepjol.info/index.php/IJOSH
International Journal of Occupational Safety and Health, Vol. 12 No. 4 (2022), 257 – 263

# Particles and fragments in unused disposable face masks: A microscopic analysis

**Scholkmann F**[1,2]
[1]Research Office for Complex Physical and Biological Systems, 8006 Zurich, Switzerland
[2]University Hospital Zurich, University of Zurich, 8091 Zurich, Switzerland

## Abstract

**Introduction:** In the context of the COVID-19 pandemic, many governments mandated the wearing of face masks by law. New research shows that these masks contain and release microplastics.

**Methods:** In the present work, five samples of surgical masks were examined microscopically for the presence of particles and fragments. The masks were purchased from two of the largest supermarket chains in Switzerland.

**Results:** Particles and fragments were found on the fibre surfaces in the inner layer of all face masks examined. The size of these objects varied in the range of about 2–40 µm, with dark spots and particles on the fibres having a smaller diameter than the more transparent fragments.

**Conclusion:** In this work, it was shown that particles and fragments in the micrometer range can be found on the inside of commercially available surgical face masks purchased in supermarkets in Switzerland. The health significance of the presence of particles and fragments in the micrometer range as demonstrated by the current investigation of surgical face masks needs to be further investigated.

**Key words:** COVID-19, Fragments, Microplastics, Particles, Surgical face masks

## Introduction

In the wake of the current novel coronavirus disease (COVID-19) pandemic, countries around the world have passed laws requiring people to wear face masks to mitigate transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes COVID-19. Wearing face masks has become a "new normal" worldwide.[1] Different masks are currently in use, from classic three-layer surgical face masks and fabric community masks to filtering facepiece particle (FFP) masks (FFP2/N95/KN95 respirators).

More and more investigations show that these face masks release microplastics into the environment, causing a new type of environmental pollution.[2-20] Even a slight mechanical deformation of a disposable face mask leads to the generation of a large number of micro- and nano-plastic particles and fragments.[21]

While on the one hand microplastics are released into the environment by the face masks, there is a possibility that they are directly inhaled during use.[22] This is problematic because the inhalation of microplastics usually has toxic effects. Exposure to microplastics is associated with pulmonary cytotoxicity[23], disruption of immune function and neurotoxicity,[24] as well as genotoxicity.[25] In a mouse model, inhalation of microplastics was shown to cause pulmonary inflammatory cell infiltration, bronchoalveolar macrophage aggregation and increased cytokine levels in bronchoalveolar lavage fluid.[26] The risk

**DOI:** https://doi.org/10.3126/ijosh.v12i4.44903

Conflicts of interest: None
Supporting agencies: None

Date of submission: 05.05.2022
Date of acceptance: 24.07.2022
Date of publication: 01.10.2022

***Corresponding Author***
PD Dr. Felix Scholkmann
Research Office for Complex Physical and Biological Systems, 8006 Zurich, Switzerland and
University Hospital Zurich, University of Zurich, 8091 Zurich, Switzerland,
E-mail: Felix.Scholkmann@usz.ch
ORCID-ID: https://orcid.org/0000-0002-1748-4852

to human health from exposure to microplastics is increasingly becoming the focus of research and consumer protection.[26-31]

Recently, a study with electron microscopy found that there are fibres, fragments and particles in the nanometre and micrometer range present on the surface of fibres from the inner facing of medical face masks, most likely nano- and microplastics.[32] The authors highlighted that currently the potential health hazard from inhaling these nano- and microplastics when wearing medical (surgical) face masks during the current COVID-19 pandemic has drawn very little attention, unfortunately. In another study, spherical- and fibre-like microplastics mostly in the 20–100 μm range were detected in the air filtered by a surgical face mask.[33] While the authors demonstrated the possibility of microplastic inhalation when wearing a face mask, they also showed that wearing a face mask reduces exposure to particulate matter pollution, especially in cities with high air pollution like Wuhan, China, where the study was conducted. While nano- and microplastics seem to be the main source of particulate matter released from face masks, trace metals and metalloids in disposable face masks have also been reported recently.[34] In this study, in exhausted material from a surgical face mask, the presence of copper, zinc, antimony and lead has been proven.

The present study aimed to perform microscopic analyses of surgical face masks available for purchase from the two largest supermarket chains in Switzerland. The objective was to detect and characterize possible particles and fragments present in these face masks.

## Methods

One package each of all the three-layered surgical face masks available was purchased at two supermarkets in Zurich. The supermarkets were branches of the two largest supermarket chains in Switzerland (Coop and Migros). Masks from five different manufacturers were thus purchased (Table 1).

Each mask package was carefully opened, the first top mask removed and discarded, and the second mask used for further analysis. All steps were performed at a cleaned workstation with disposable gloves. The mask was removed from the package with tweezers and placed under the microscope. Two light microscopes were used for the analysis (Eclipse E200, Nikon Inc., Tokyo, Japan, with DynoEde AM7025X 5 MP CMOS camera, Dino-Lite, Naarden, Netherlands; Axiolab 5 with Axiocam 208 color 8.3 MP CMOS camera, Carl Zeiss, Oberkochen, Germany).

The inside layers of the masks were examined microscopically using 200 x magnification for the presence of particles and fragments on or between the mask fibres. In addition, a 2 x 2 cm area on the inside of each mask was systematically examined by counting all particles and fragments and measuring their diameter.

## Results

Particles and fragments were found on the fibre surfaces in the inner layer of all face masks examined. The size of these objects varied in the range of about 2–40 μm, with dark spots and particles on the fibres having a smaller diameter than the more transparent fragments. Figure 1 shows examples of the objects found in all the masks studied. The distribution of the diameters of the objects is depicted in Figure 2.

In masks #1, #2 and #3, dark spots/particles were found on the fiibres (Fig. 1A, 1B, 1E). Mask #1 exhibited two distinct dark spots/particles with different size distributions (2 ± 1 μm and 6 ± 3 μm). The size of the dark spots/particles on fibres was 10 ± 3 μm in mask #2 and 9 ± 3 μm in mask #3. In mask #2, a large single dark object with a length of about 100 μm and a diameter of about 25 μm was found (Fig. 1F).

Fragments of a rather transparent color attached to fibres were detected in all mask samples (Fig. 1C, 1D, 1G-L) with a typical size of 15–20 μm (mask #1: 15 ± 6 μm, mask #2: 20 ± 10 μm, mask #3: 15 ± 6 μm, mask #4: 18 ± 9 μm and mask #5: 13 ± 9 μm).

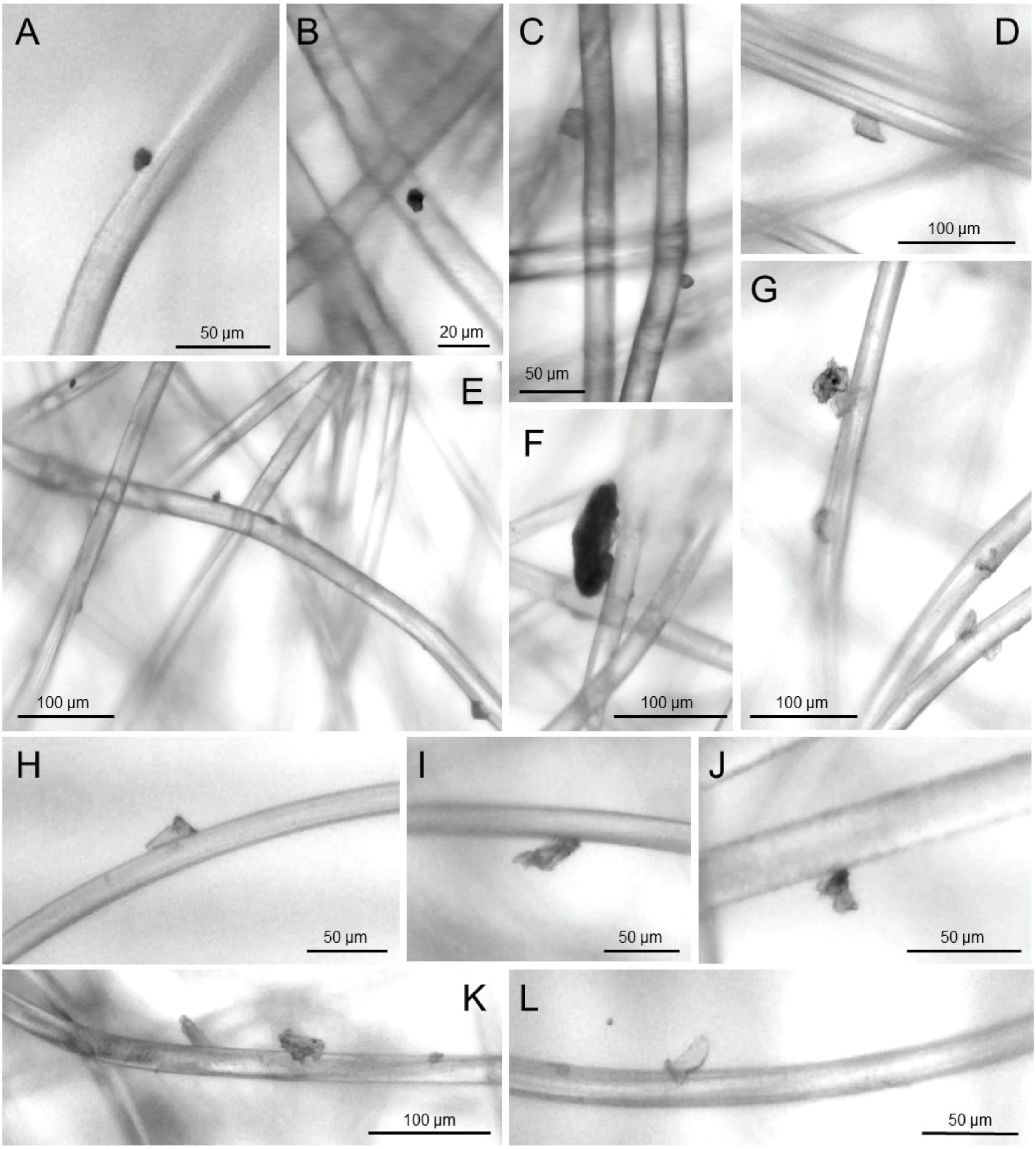


**Figure 1:** Optical microscopic images of particles and fragments on fibres of surgical face masks. A–C: mask #1, D: mask #4, E–G: mask #2, H–I: mask #4, J: mask #3, K–L: mask #5.

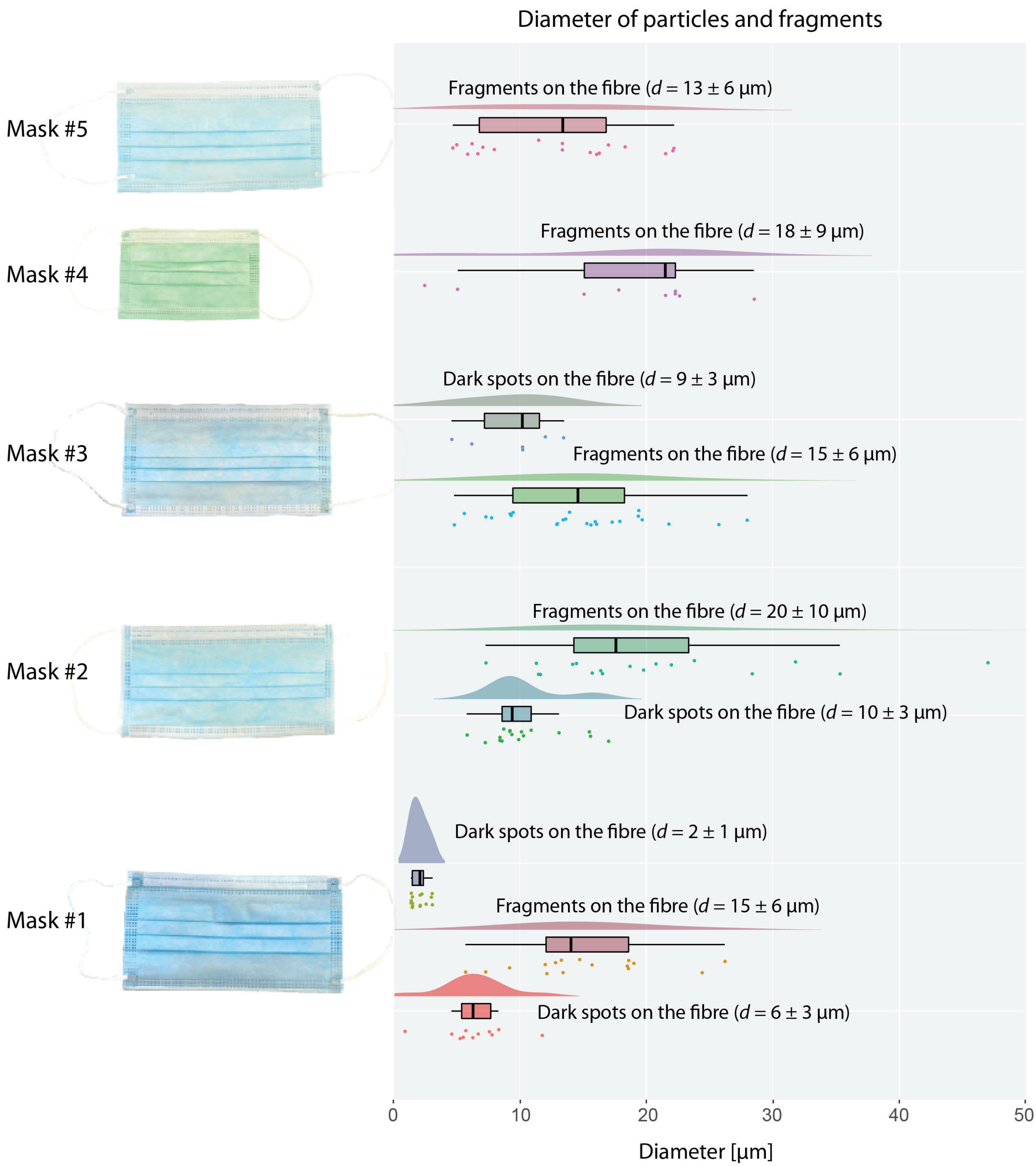


**Figure 2:** Size distributions of particles and fragments were detected in a randomly chosen 2 x 2 cm area of the inner layer of the five types of surgical face masks investigated. *d*: diameter.

**Table 1:** Masks purchased at Swiss supermarkets and analyzed in the present study. OL: outer layer, IL: inner layer.

| Mask ID | Product name | Color | Size | LOT | Manufacturer | Purchased from |
|---|---|---|---|---|---|---|
| #5 | Medical surgical face mask | OL: blue<br>IL: white | Adult | 20200909 | Suzhou ZOEY Medical Devices Co., Ltd., China | Migros, Zurich, Switzerland |
| #4 | Wero Swiss Protect Small Size | OL: green<br>IL: white | Child | 485223 | Wernli AG, Switzerland | Migros, Zurich, Switzerland |
| #3 | Face Mask | OL: blue<br>IL: white | Adult | 11112020 | Sunsmed protective products Ltd., China | Migros, Zurich, Switzerland |
| #2 | Medi-Inn Mundschutz | OL: blue<br>IL: white | Adult | E2017468 | BODY Products relax Pharma und Kosmetik GmbH, Germany | Migros, Zurich, Switzerland |
| #1 | PM Plus Medical Einweg-Hygienemaske | OL: blue<br>IL: white | Adult | 30092575 | Foshan Nanhai Plus Medical Co., Ltd., China | Coop, Zurich, Switzerland |

## Discussion

In this work, it was shown that particles and fragments in the micrometer range can be found on the inside of commercially available surgical face masks purchased in supermarkets in Switzerland. In general, two classes of objects were found: dark smaller dots/particles on the fibres and larger, more transparent fragments also on the fibres.

These results are in line with the findings of Han & He[32] and Li et al.[33] who also found particles and fragments in this size range in face masks. The particles and fragments detected in the current work are probably microplastics, although metallic objects are also possible as Bussan et al.[34] detected them, at least as far as the dark (i.e. opaque) objects are concerned.

The presence of microplastics or impurities in the form of particles and fragments in the nanometre and micrometer range is currently not considered in the quality standards for face masks. As Han & He point out, neither the ASTM standards (F1862, F2100, F2299), the NIOSH regulation (42 CFR 83) nor the ISO standards (ISO 22609, 16900) and Chinese standards (GB 19083, 2626; GB/T 32610, 38880; YY 0469; YY/T 0969) on masks and respirators cover the presence of these contaminants in masks.[32] There is an apparent regulatory gap concerning this possible hazardous contamination in face masks.

The particles and fragments detected here can detach from the fibres and be inhaled. This seems to be the case especially when the masks are mechanically deformed (e.g. by folding them, putting them in a trouser pocket, and putting them on several times).

In addition to the presence of particles and fragments in masks, it has also been shown that masks can contain various chemical pollutants. For example, 12 high-risk volatile chemicals (1, 4-dichlorobenzene, toluene, xylenes (p, m, o), ethylene oxide, ethylbenzene, caprolactam, N,N-dimethylacetamide, N,N-dimethylformamide, N-methylpyrrolidone and dimethyl glutarate) were recently detected in surgical face masks.[35] Some of these substances are considered carcinogenic.

## Conclusion

The health significance of the presence of particles and fragments in the micrometer range in surgical face masks as demonstrated by the current investigation remains to be investigated. However, since inhaled microplastics can trigger pathophysiological processes, this contamination in the masks should be further investigated, and quality standards should be revised and supplemented. When masks are worn, and especially when they are worn regularly and for prolonged periods, a balance should be struck between the exposure to toxic substances caused by wearing masks and the exposure to pathophysiologically relevant substances (viruses, microorganisms, pollutants) prevented by wearing them. This should be considered especially during the current COVID-19 pandemic.

**Acknowledgments:** I would like to thank Rachel Scholkmann for proofreading this manuscript.

## References


1. Rab S, Javaid M, Haleem A, Vaishya R. Face masks are new normal after COVID-19 pandemic. Diabetes Metab Syndr. 2020;14(6):1617-9. Available from: https://doi.org/10.1016/j.dsx.2020.08.021
2. Wu P, Li J, Lu X, Tang Y, Cai Z. Release of tens of thousands of microfibers from discarded face masks under simulated environmental conditions. Sci Total Environ. 2022;806(Pt 2):150458. Available from: https://doi.org/10.1016/j.scitotenv.2021.150458
3. Aragaw TA. Surgical face masks as a potential source for microplastic pollution in the COVID-19 scenario. Mar Pollut Bull. 2020;159:111517. Available from: https://doi.org/10.1016/j.marpolbul.2020.111517
4. Fadare OO, Okoffo ED. Covid-19 face masks: A potential source of microplastic fibers in the environment. Sci Total Environ. 2020;737:140279. Available from: https://doi.org/10.1016/j.scitotenv.2020.140279
5. Chen X, Chen X, Liu Q, Zhao Q, Xiong X, Wu C. Used disposable face masks are significant sources of microplastics to environment. Environ Pollut. 2021;285:117485. Available from: https://doi.org/10.1016/j.envpol.2021.117485
6. Shruti VC, Perez-Guevara F, Elizalde-Martinez I, Kutralam-Muniasamy G. Reusable masks for COVID-19: A missing piece of the microplastic problem during the global health crisis. Mar Pollut Bull. 2020;161(Pt B):111777. Available from: https://doi.org/10.1016/j.marpolbul.2020.111777
7. Shen M, Zeng Z, Song B, Yi H, Hu T, Zhang Y, et al. Neglected microplastics pollution in global COVID-19: Disposable surgical masks. Sci Total Environ. 2021;790:148130. Available from: https://doi.org/10.1016/j.scitotenv.2021
8. Dissanayake J, Torres-Quiroz C, Mahato J, Park J. Facemasks: A Looming Microplastic Crisis. Int J Environ Res Public Health. 2021;18(13):7068. Available from: https://doi.org/10.3390/ijerph18137068
9. Wang Z, An C, Chen X, Lee K, Zhang B, Feng Q. Disposable masks release microplastics to the aqueous environment with exacerbation by natural weathering. J Hazard Mater. 2021;417:126036. Available from: https://doi.org/10.1016/j.jhazmat.2021.126036
10. Prata JC, Silva ALP, Duarte AC, Rocha-Santos T. Disposable over Reusable Face Masks: Public Safety or Environmental Disaster? Environments. 2021;8(4):31. Available from: https://doi.org/10.3390/environments8040031
11. Chowdhury H, Chowdhury T, Sait SM. Estimating marine plastic pollution from COVID-19 face masks in coastal regions. Mar Pollut Bull. 2021;168:112419. Available from: https://doi.org/10.1016/j.marpolbul.2021.112419
12. Akber Abbasi S, Khalil AB, Arslan M. Extensive use of face masks during COVID-19 pandemic: (micro-) plastic pollution and potential health concerns in the Arabian Peninsula. Saudi J Biol Sci. 2020;27(12):3181-6. Available from: https://doi.org/10.1016/j.sjbs.2020.09.054
13. Hu T, Shen M, Tang W. Wet wipes and disposable surgical masks are becoming new sources of fiber microplastic pollution during global COVID-19. Environ Sci Pollut Res Int. 2022;29(1):284-92. Available from: https://doi.org/10.1007/s11356-021-17408-3
14. Liang H, Ji Y, Ge W, Wu J, Song N, Yin Z, et al. Release kinetics of microplastics from disposable face masks into the aqueous environment. Sci Total Environ. 2022 Apr 10;816:151650. Available from: https://doi.org/10.1016/j.scitotenv.2021.151650
15. Mghili B, Analla M, Aksissou M. Face masks related to COVID-19 in the beaches of the Moroccan Mediterranean: An emerging source of plastic pollution. Mar Pollut Bull. 2022;174:113181. Available from: https://doi.org/10.1016/j.marpolbul.2021.113181
16. Sun J, Yang S, Zhou G-J, Zhang K, Lu Y, Jin Q, et al. Release of Microplastics from Discarded Surgical Masks and Their Adverse Impacts on the Marine Copepod Tigriopus japonicus. Environ Sci Technol Lett. 2021;8(12):1065-70. Available from: https://doi.org/10.1021/acs.estlett.1c00748
17. Spennemann DHR. COVID-19 Face Masks as a Long-Term Source of Microplastics in Recycled Urban Green Waste. Sustainability. 2021;14(1):207. Available from: https://doi.org/10.3390/su14010207
18. Jemec Kokalj A, Dolar A, Drobne D, Marinšek M, Dolenec M, Škrlep L, et al. Environmental hazard of polypropylene microplastics from disposable medical masks: acute toxicity towards Daphnia magna and current knowledge on other polypropylene microplastics. Microplast nanoplast. 2022;2(1):1. Available from: https://doi.org/10.1186/s43591-021-00020-0
19. De Felice B, Antenucci S, Ortenzi MA, Parolini M. Laundering of face masks represents an additional source of synthetic and natural microfibers to aquatic ecosystems. Sci Total Environ. 2022;806(Pt 1):150495. Available from: https://doi.org/10.1016/j.scitotenv.2021.150495
20. Saliu F, Veronelli M, Raguso C, Barana D, Galli P, Lasagni M. The release process of microfibers: from surgical face masks into the marine environment. Environ Adv. 2021;4:100042. Available from: https://doi.org/10.1016/j.envadv.2021.100042

21. Morgana S, Casentini B, Amalfitano S. Uncovering the release of micro/nanoplastics from disposable face masks at times of COVID-19. J Hazard Mater. 2021;419:126507. Available from: https://doi.org/10.1016/j.jhazmat.2021.126507
22. De-la-Torre GE, Pizarro-Ortega CI, Dioses-Salinas DC, Ammendolia J, Okoffo ED. Investigating the current status of COVID-19 related plastics and their potential impact on human health. Curr Opin Toxicol. 2021;27:47-53. Available from: https://doi.org/10.1016/j.cotox.2021.08.002
23. Dong C-D, Chen C-W, Chen Y-C, Chen H-H, Lee J-S, Lin C-H. Polystyrene microplastic particles: In vitro pulmonary toxicity assessment. J Hazard Mater. 2020;385:121575. Available from: https://doi.org/10.1016/j.jhazmat.2019.121575
24. Prata JC, da Costa JP, Lopes I, Duarte AC, Rocha-Santos T. Environmental exposure to microplastics: An overview on possible human health effects. Sci Total Environ. 2020;702:134455. Available from: https://doi.org/10.1016/j.scitotenv.2019.134455
25. Tagorti G, Kaya B. Genotoxic effect of microplastics and COVID-19: The hidden threat. Chemosphere. 2022;286(Pt 3):131898. Available from: https://doi.org/10.1016/j.chemosphere.2021.131898
26. Lu L, Luo T, Zhao Y, Cai C, Fu Z, Jin Y. Interaction between microplastics and microorganism as well as gut microbiota: A consideration on environmental animal and human health. Sci Total Environ. 2019;667:94-100. Available from: https://doi.org/10.1016/j.scitotenv.2019.02.380
27. Vethaak AD, Legler J. Microplastics and human health. Science. 2021;371(6530):672-4. Available from: https://doi.org/10.1126/science.abe5041
28. Campanale C, Massarelli C, Savino I, Locaputo V, Uricchio VF. A Detailed Review Study on Potential Effects of Microplastics and Additives of Concern on Human Health. Int J Environ Res Public Health. 2020;17(4):1212. Available from: https://doi.org/10.3390/ijerph17041212
29. De-la-Torre GE. Microplastics: an emerging threat to food security and human health. J Food Sci Technol. 2020;57(5):1601-8. Available from: https://doi.org/10.1007/s13197-019-04138-1
30. Prata JC. Airborne microplastics: Consequences to human health? Environ Pollut. 2018;234:115-26. Available from: https://doi.org/10.1016/j.envpol.2017.11.043
31. Prata JC, da Costa JP, Lopes I, Andrady AL, Duarte AC, Rocha-Santos T. A One Health perspective of the impacts of microplastics on animal, human and environmental health. Sci Total Environ. 2021;777:146094. Available from: https://doi.org/10.1016/j.scitotenv.2021.146094
32. Han J, He S. Need for assessing the inhalation of micro(nano)plastic debris shed from masks, respirators, and home-made face coverings during the COVID-19 pandemic. Environ Pollut. 2021;268(Pt B):115728. Available from: https://doi.org/ 10.1016/j.envpol.2020.115728
33. Li L, Zhao X, Li Z, Song K. COVID-19: Performance study of microplastic inhalation risk posed by wearing masks. J Hazard Mater. 2021;411:124955. Available from: https://doi.org/10.1016/j.jhazmat.2020.124955
34. Bussan DD, Snaychuk L, Bartzas G, Douvris C. Quantification of trace elements in surgical and KN95 face masks widely used during the SARS-COVID-19 pandemic. Sci Total Environ. 2022;814:151924. Available from: https://doi.org/10.1016/j.scitotenv.2021.151924
35. Liu Y, Wang Z, Wang W, Xing J, Zhang Q, Ma Q, et al. Non-targeted analysis of unknown volatile chemicals in medical masks. Environ Int. 2022;161:107122. Available from: https://doi.org/10.1016/j.envint.2022.107122