Disposable Face Masks: Analysis of the Release of Synthetic Micro and Nano Particles and Chemical Contaminants – Linked to the COVID-19 Pandemic

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Abstract

With the increase on the manufacturing and use of disposable face mask (DPFs) due to the COVID- 19 pandemic, the inappropriate and unregulated disposal of these items is a concerning cause of the intensification of plastic as an environmental problem nowadays. This study focuses on the emission of different contaminants from 7 DPFs brands (a total of 9 batches) that were immersed in deionized water in order to emulate environmental conditions once these DPFs are discarded and released into the environment. 7 different brands of DPFs (a total of 9 batches) were purchased from several manufacturers and suppliers and pollutants were filtered and deposited in membranes. These results have been published (https://doi.org/10.1016/j.watres.2021.117033).

Methodology

Leaching and filtration of particles

10 face masks for each batch were submerged in 1.5 L deionized water for 4 hours and gently agitated by stirring every hour to ensure complete coverage and contact of DPFs with water. Post submersion, the eluent (leachate) was then filtered under vacuum through a 0.1 µm Al_2O_3 membrane filter.

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ISBN: 978-81-947843-7-1 (eBook), 978-81-954993-1-1 (Paperback),

Microscopy and FTIR

To determine the coverage of the contamination by particles, light microscopy was put in place. For scanning electronic microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analysis, samples were mounted on carbon tape and placed in vacuums chamber. Fourier transform infrared spectroscopy (FTIR) was used for quick solid sample analysis and surface characterisation.

ICP-MS elemental analysis and LC-UV and LC-MS accurate mass of leachate DPFs were submerged in 250 mL of deionized water for a period of 24 hours. To check the background interference, a procedural blank was run with samples. To check for carryover, blanks were run after every sample and after highest calibration. A subsample of the leachate was analysed for polar organic compounds by direct injection (5 µL) on LC-UV for initial sample contamination screening and LC-MS for compound identification. Procedural blanks were run pre and post samples.

Results

Face mask and Filtrate characterisation: Microscopy and FTIR analysis

9 separate batches of DPFs (from 7 brands) were tested for their potential capacities of releasing pollutants in water. All 9 batches of DPFs emitted fibres (believed to be made of polypropylene) and crystalline fragments (believed to be of siliceous composition).

Light microscopy for some DFMs presented many different coloured fibres, suggesting that, in the manufacturing process, some of them are stained with dying agent that seems to tarnish also the membranes during the filtration process.

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Polypropylene was confirmed as the primarily material use on the manufacturing of the face masks by FTIR analysis, with some additional functionalization seen in some dyed brands particularly on the coloured sides. The use of SEM-EDX demonstrated that the size of the particles deposited on the membranes are in the micro (<1 mm) and nano (submicron particle size 0.1-1 µm) range. All DFMs in the study released also a significant amount of grain sized particles measured between 360 nm- 500 µm on SEM. The analysis with EDX suggested the elemental composition of particles. A high percentage of carbon was found on fibrous particles, most likely derived from polypropylene. High percentages of silicon and oxygen were found in the majority of the grains, more likely to be compositions of silica. Associated with these particles, there was often presence of heavy metals associated, especially in the coloured face masks. Some heavy metals were located on grain particles of children DPFs. These heavy metals (such as such as Pb, Cd, Sb and Cu) are common chemical additives added during plastic manufacture.

Leachable metals and organic compounds: ICP-MS and LC-MS analysis

ICP-MS analysis demonstrated the presence of heavy metals released from the DPFs into the leachate, showing disconcerting levels of Sb on some DFMs (ranging from 111-393 µg/L). All face masks appeared to release Cu with levels ranging from 0.85 µg/L to highest levels of 4.17 µg/L. PB was also observed in some samples, the highest value being of 6.79 µg/L.

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Sample	Cd (µg/L)	Co (µg/L)	Cu (µg/L)	Pb (µg/L)	Sb (µg/L)	Ti (µg/L)
Procedural Blank	N.D*	N.D	N.D	N.D	N.D	N.D
Face mask 2 (Leachate)	N.D	N.D	4.17	0.01	1.06	0.64
Face mask 4 (Leachate)	0.01	0.54	1.87	0.62	N.D	0.27
Face mask 4 (Leachate) repeat	0.04	0.59	1.22	0.89	N.D	N.D
Face mask 5 (Leachate)	N.D	N.D	0.85	0.75	3.07	N.D
Face mask 6 (Leachate)	1.92	N.D	1.80	6.79	N.D	N.D
Face mask 7 a (Leachate)	0.53	N.D	2.06	1.62	111	N.D
Face mask 7 b (Leachate)	N.D	N.D	2.31	N.D	393	0.12
Face mask 7 c (Leachate)	N.D	N.D	4.00	N.D	147	0.06

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Biography

Dr. Sarper Sarp (Co-PI), is a Lecturer in Chemical Engineering at Swansea University (SU). He has 17 years of experience in water quality, advanced water monitoring of micro-pollutants and water treatment systems. He has authored 40 papers in international peer-reviewed journals (h-index: 18, Citations: 1,766), has five intellectual property documents, and currently serves as Editorial Board Member for the leading environmental and water quality journals *ES&T Water and Desalination*. In 2020, his research team published a novel analytical sample preparation and analysis method that is capable of identifying and semi-quantifying nano-size plastics in water sources (https://www.sciencedirect.com/science/article/abs/pii/S0045653520303726) His team later used the same method to identify micro and nano particle release from disposable face masks when littered in the environment (https://www.sciencedirect.com/science/article/abs/pii/S0043135421002311)

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