미세플라스틱과 호흡기질환

가톨릭대학교 최준영

Microplastic is ubiquitous

- A wide variety and large quantity of plastic is being consumed on a large scale by human beings.

- Plastic has desirable characteristics

  : durability, resistance, low cost.

- Air, soil and water + plastic

  → smaller particles called micro and nanoplastics (NMPs).

- Plastic particles can be found in soil, water, and air.


AQUAFINA
eau pure, goût parfait
Eau purifiée par
osmose inversée
500 mL

frontiers in Chemistry

ORIGINAL RESEARCH
published: 11 September 2018
doi: 10.3389/fchem.2018.00407

Synthetic Polymer Contamination in Bottled Water

Sherri A. Mason*, Victoria G. Welch and Joseph Neratko

Department of Chemistry, State University of New York at Fredonia, Fredonia, NY, United States

259 bottles were analyzed

- 사출성형
- 가수분해

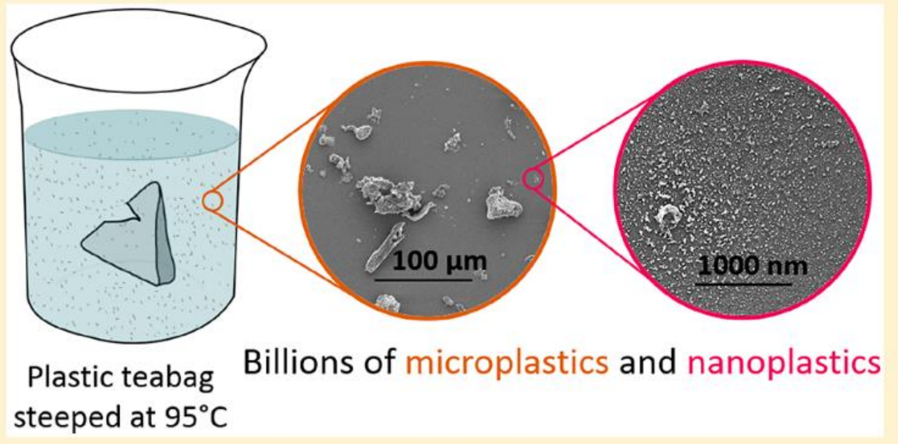
Fobes 2018, Front Chem. 2018 Sep 11;6:407.

Environmental Science & Technology
Article
Cite This: Environ. Sci. Technol. 2019, 53, 12300–12310
pubs.acs.org/est

Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea

Laura M. Hernandez,[†] Elvis Genbo Xu,[†] Hans C. E. Larsson,[‡] Rui Tahara,[‡] Vimal B. Maisuria,[†] and Nathalie Tufenkji*,[†]

[†]Department of Chemical Engineering, McGill University, Montreal, Quebec H3A 0C5, Canada
[‡]Redpath Museum, McGill University, Montreal, Quebec H3A 0C4, Canada

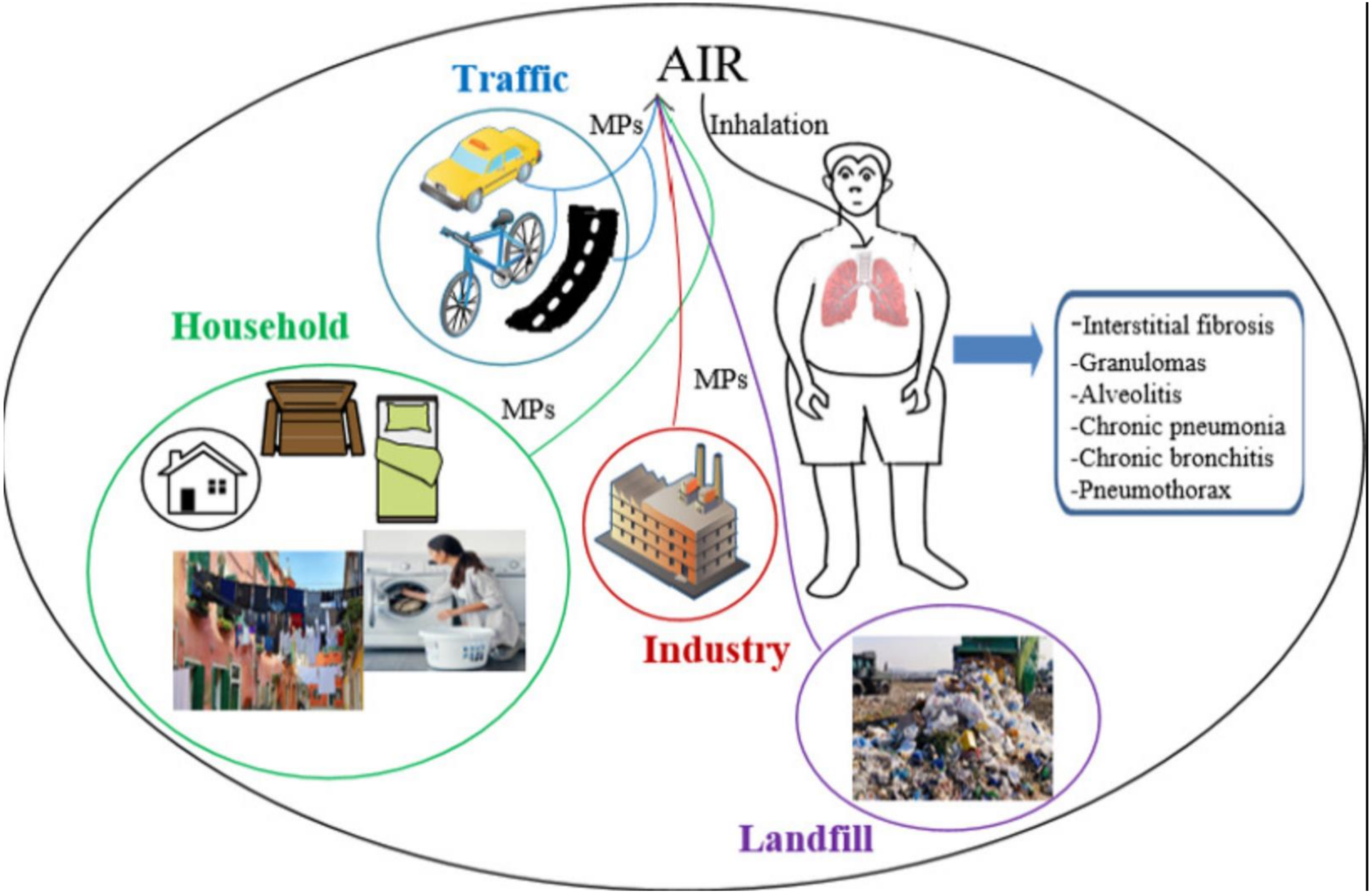


3.1 billion nanoplastics per one cup of tea

Exposure to microplastics

- Drinking-water
- Food (seafood)
- Food packaging
- Indoor/outdoor air

Microplastic in drinking water, WHO, 2019
Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health, WHO 2022


AIR
Traffic
MPs
Inhalation
Household
MPs
MPs
Industry
Landfill
-Interstitial fibrosis
-Granulomas
-Alveolitis
-Chronic pneumonia
-Chronic bronchitis
-Pneumothorax

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Plastics

Microplastics found in human blood for first time

Exclusive: The discovery shows the particles can travel around the body and may lodge in organs

Microplastics cause damage to human cells in the laboratory. Photograph: David Kelly/Photograph David Kelly

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The Guardian, Thu 24 Mar 2022

Environ Int. 2022 May;163:107199

Environmental Science & Technology
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Article

Detection and Analysis of Microplastics in Human Sputum

Shumin Huang,[▽] Xiaoxin Huang,[▽] Ran Bi, Qiuxia Guo, Xiaolin Yu, Qinghui Zeng, Ziyu Huang, Tianming Liu, Haisheng Wu, Yuliang Chen, Jialong Xu, Yinge Wu,[*,○] and Pi Guo[*,○]

Environ Sci Technol. 2022 Feb 15;56(4):2476-2486.

toxics

MDPI

Article

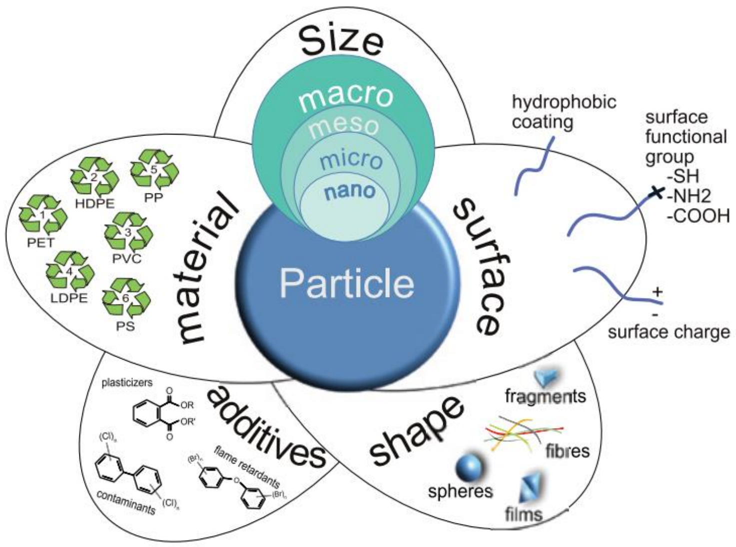
First Evidence of Microplastics in Human Urine, a Preliminary Study of Intake in the Human Body

Concetta Pironti [1,†], Valentina Notarstefano [2,†], Maria Ricciardi [3], Oriana Motta [1,*], Elisabetta Giorgini [2] and Luigi Montano [4,5,*]

Toxics. 2022 Dec 30;11(1):40.

Definitions

- Microplastic (MP) : plastic particles < 5mm in diameter
- Nanoplastic (NP) : plastic particle < 1000nm (1um) in diameter



Attributes of NMP to be considered in assessing both exposure and hazard

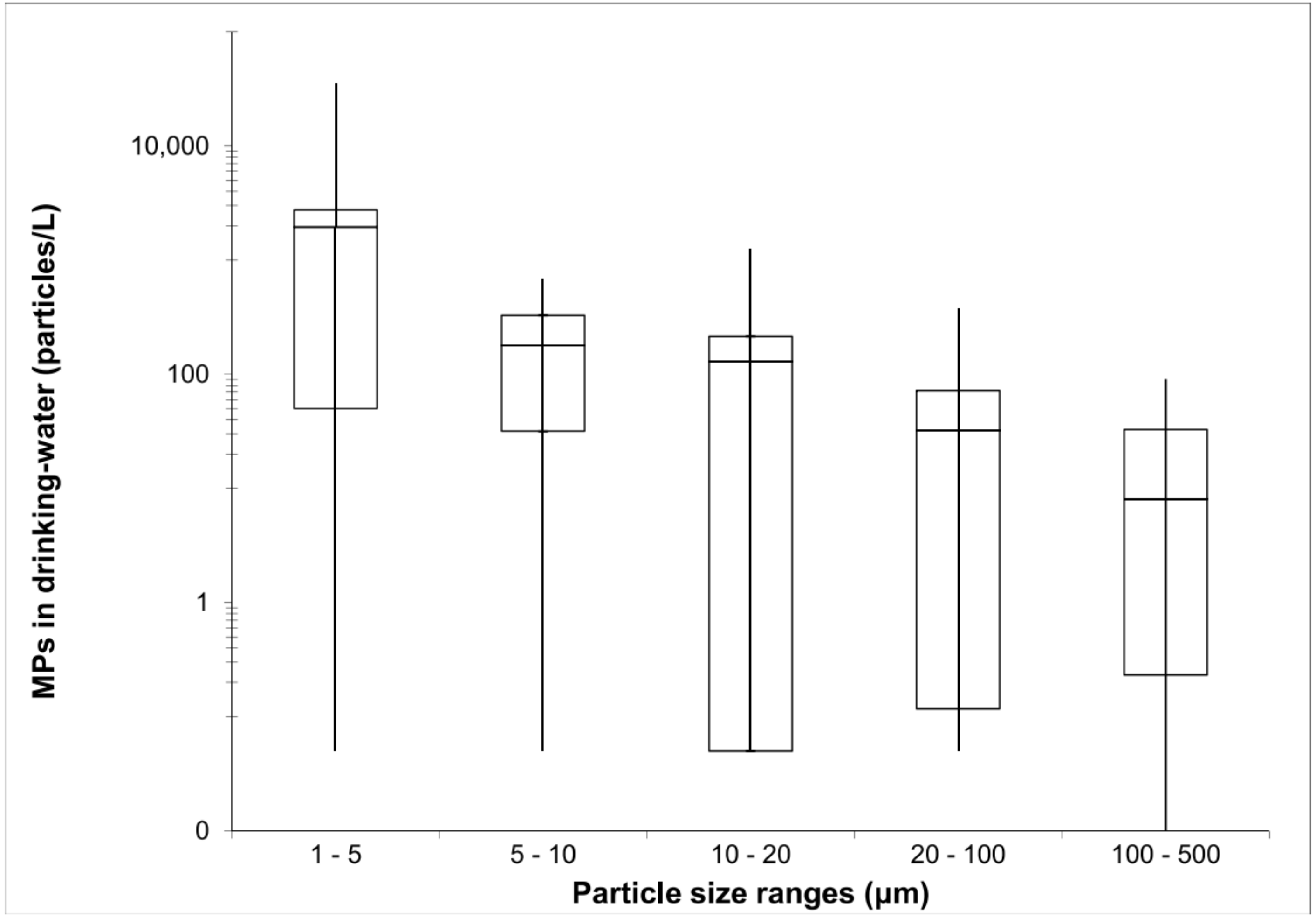
A scientific perspective on microplastics in nature and society. Berlin: Science Advice for Policy by European Academies; 2019 (10.26356/microplastics).
Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health, WHO 2022

Table 2. Recent studies on the numbers and characteristics of microplastic or microplastic-like particles in drinking-water

Reference	Water type	Lower size bound (µm)	Particles/L in sample (average)	Particles/L in blanks (average)	Particle size (µm)	Predominant particle shape	Predominant polymer type	Quality score (TAS)[a]
105	Bottled (mineral water)	1		384	Most particles < 5 (> 75% in glass and > 95% in plastic bottles)	No discussion of shapes	PET in plastic bottles, polyethylene and styrene butadiene copolymer in glass	13
	Glass		3074–6292					
	Single-use PET		2649					
	Reusable PET		4889					
106	Drinking-water treatment plant from surface sources (3 sites): raw, treated	1	628 338 369	< 5% of counts in samples	≤ 95% of particles 1–10	Fragments, closely followed by fibres	PET but also polypropylene, polyethylene, polyacrylamide	11
107	Bottled	5–20		14 ± 13	Typically, 40–50% in 5–10 range; > 80% < 20	No discussion of shape; described as fragments	PET but also polypropylene, polyethylene	14
	Single-use		14					
	Returnable		118					
	Glass		50					
	Beverage carton		11					
104	Bottled	6.5–100 lower bound microscop-ically and in software	315	23.5	Not further specified		No characterization	14
102	Tap from groundwater sources	10–100	0.2, 0.8 and 0.0 (LOD, 0.3)	Unknown	Mainly 20–100	Fragments	PET, polypropylene, ABS, polyurethane	14
108	Tap from groundwater sources	20	0.0007	0.67 particles/L 0.3 fibres/L	50–150	Fragments	Polyester, PVC, polyethylene, polyamide, epoxy resin	15
103	Tap from 24 sources	60	Average not reported, as only one result (5.5) > LOQ	0.5 (LOQ = 4.1 LOD = 0.9)	Not specified	Not specified	No characterization	9
104	Bottled	> 100	10.4	4.15	Not further specified	Fragments (66%), fibres (13%), films (12%)	Polypropylene (54%)	14
102	Tap from groundwater sources	> 100 (10-µm sieve size)	0.312 (LOD, 0.58)	0.26	Not further specified	Fibres (82%), fragments (14%), films (4%)	PET, polypropylene, polystyrene	14
91	Tap from unspecified sources	100 (lowest reported)	5.45	0.33 particles/L (5 particles in 30 500-mL blanks	Fibre lengths, 100–5000	Mainly fibres (98.3%)	No characterization	8
109	Bottled	0.5	5.42×10^7	1×10^7 (estimated)	Range, 1.28–4.2	Not reported	Not reported	10
110	Tap water	1	440	2.4	3–4453; Mean, 66	> 50% fragments	Polyethylene and polypropylene	13
111	Drinking-water treatment plant: raw and treated	1	6614 ± 1132 (raw) 930 ± 72 (treated)	< 5% of samples	84.4–86.7% 1–5	> 50% fibres	PET, polyethylene, polypropylene	12
112	Bottled	3	148 ± 253	0	≥ 3 µm	Not reported	Not reported	15
113	Bottled	6.5	118 ± 88 14 ± 14 50 ± 52 81.0 ± 3.0 26.0 ± 2.0 12.0 ± 1.0	 15 8 6	≥ 5 µm (returnable bottles) ≥ 5 µm (single-use bottles) ≥ 5 µm (glass bottles) 6.5–20 µm 20–50 µm ≥ 50 µm	62.8% fibres, 37.2% fragments	Polyethylene, polypropylene, PET	14
100	Drinking-water treatment plant: raw and treated	25	4.9 (raw) 0.0011 (treated)	Depending on polymer composi-tion. LOD, 1.1–65; LOQ, 3.3–197	> 25	Not reported	ABS, polystyrene	16
114	Tap water	500	18 ± 7 (range, 5–91)	1	50% < 0.5 mm; 25% 0.5–1 mm	Fibres	Poly (trimethylene terephthalate); epoxy resin	14
115	Tap water from groundwater wells	Not defined	2.8	Not reported	Not reported	Fibres	Polyethylene	6
116	Tap water	10	0.7 ± 0.6 (range, 0.3–1.6)	Not reported	≥ 500 µm (> 50%)	Fibres (99.2%)	PET and rayon	11
117	Tap and bottled water	25	2.1 ± 5.0 (range, 0.99–26)	Not reported	25–500	Not reported	Polyethylene, polystyrene, PET	10
118	Tap water	50	0.6 (range, 0.24–1.00)	Not reported	≥ 100 µm (> 80%)	Fragments (77.5-93.6%)	Polyethylene, PET, polypropylene	11
119	Tap water	1	343.5	1-7	1–10 (85%)	Fragments	Polyethylene, polypropylene, PET	11
120	Bottled	15	6–58	Not reported	40–723	Fragments and Fibres	Not reported	6
121	Tap water	Not defined	39 ± 44 (range, 1.9–225)	Not reported	19.2–4200	Fragments	polystyrene, styrene-ethylene-butylene, polypropylene, polyester	11
122	Groundwater	Not defined	38 ± 8 (range, 16–97)	Not reported	18–491	Fragments 94%)	Polyethylene, polypropylene, PVC, nylon, PET	15
123	Tap water		13.23	< 5%	100–200	Fragments	Nylon, polyester	9

Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health, WHO 2022

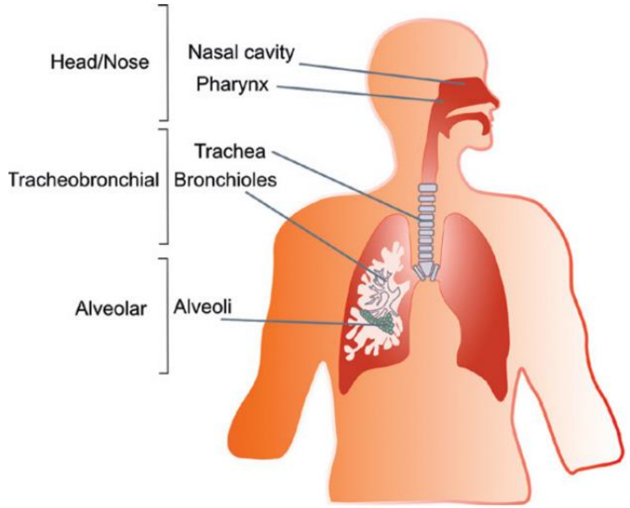
Fig. 3 Concentrations of MP in drinking-water according to particle size in studies with a total assessment score ≥ 11 and in which particles were verified as plastic



Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health, WHO 2022

Occurrence in air

- Inhalable fraction : 2.5-10um
- Microplastic < 5 µm : cannot be cleared by nasal mucus and can be inhaled directly into the lungs



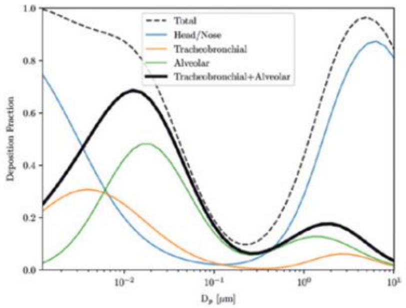


Table 3. Studies with a total assessment score > 10 of microplastic particles in indoor and outdoor air at urban and rural sites

Reference	Sample type	Lower size bound (µm)	Particle concentration (average)	Number of particles in blanks (average)	Particle size (µm)[a]	Predominant particle shape	Predominant polymer type	Quality score[b]
157	Air (indoor and outdoor)	10	1583 ± 1181 MP/m³ (indoor); 189 ± 85 MP/m³	3.3 ± 1.8 MP/filter	> 90% < 100 µm, the 5–30 µm fraction representing 54.1–65.2% of total	Fragments > 80%	Indoor: Polyester, polyamide, polypropylene Outdoor: Polyethylene, polystyrene, polyester	18
158	Air (outdoor)	10	282 ± 127 MP/m³ (range, 104–650)	3.9 ± 2.2 MP/filter	73.5–96.6% represented by 5–30-µm fraction	Fragments (88.2%)	Polyethylene, polyester, polystyrene	18
159	Air (indoor)	11	9.3 ± 5.8 particles/m³	7.7 ± 3.8 MP/blank, data not corrected	36 and 21 for the major and minor dimensions	13% fibres, 87% fragments	81% polyester, 6% polyethylene, 5% polyamide, 2% polypropylene and 6% other polymers; non-synthetic, 95% protein, 5% cellulose; MP > 4% total particles	15
154	Air (indoor and outdoor)	20	3.3 fibres and 12.6 fragments/m3 indoors; 0.6 fibres and 5.6 fragments/m³ outdoors	2.4 fibres and 12.2 fragments per filter indoors; 0.4 fibres and 6.3 fragments per filter outdoors	Fibre lengths: indoors 641 µm; outdoor 616 µm; approx. 30% of fibres 100–300 µm Fragments: outdoors 104 µm; indoors 58.6 µm	Fragments	Polystyrene, PET, polyethylene	15
156	Air (outdoor)	12	0.41 MP/m³ (0–2 MP/m³)	No MP in one blank collected	246.52 µm (12.35–2191.32 µm)	Fibres (43%), fragments (48%), beads (9%)	PET (51%), epoxy resin (19%), polyethylene (12%), alkyd resin (8%); fibrous PET (87%)	13
142	Deposition	10	365 ± 69 particles/m² per day (range, 29–462)	3 ± 1 fibres, 1 ± 1 film and 8 ± 1 fragments per filter	Most MP < 50 µm, fibre lengths predominantly 100–200 µm and 200–300 µm (max, 3000 µm); films, 50–200 µm	Fragments > fibres > films	Polystyrene (as fragments) followed by polyethylene	12

Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health, WHO 2022

Journal of Hazardous Materials 417 (2021) 126007

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/jhazmat

Airborne microplastics in indoor and outdoor environments of a coastal city in Eastern China

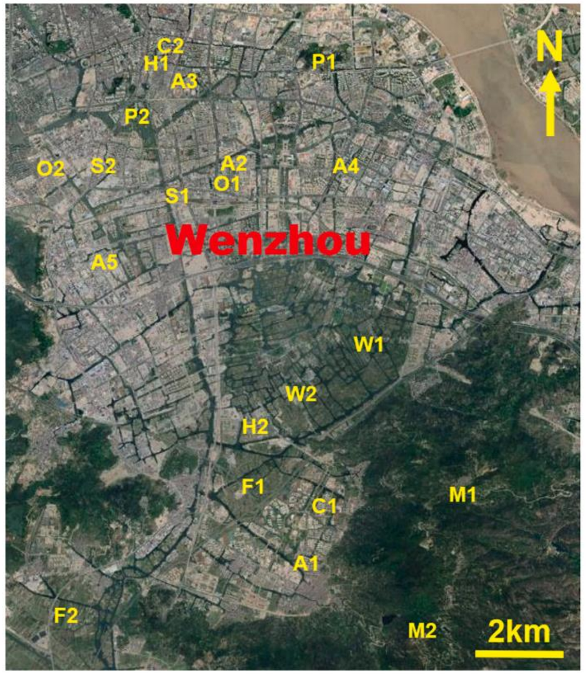
Zhonglu Liao [a], Xiaoliang Ji [a], Yuan Ma [a], Baoqiang Lv [b], Wei Huang [c], Xuan Zhu [a], Mingzhu Fang [a], Qi Wang [b], Xuedong Wang [a,*], Randy Dahlgren [a,d], Xu Shang [a,*]

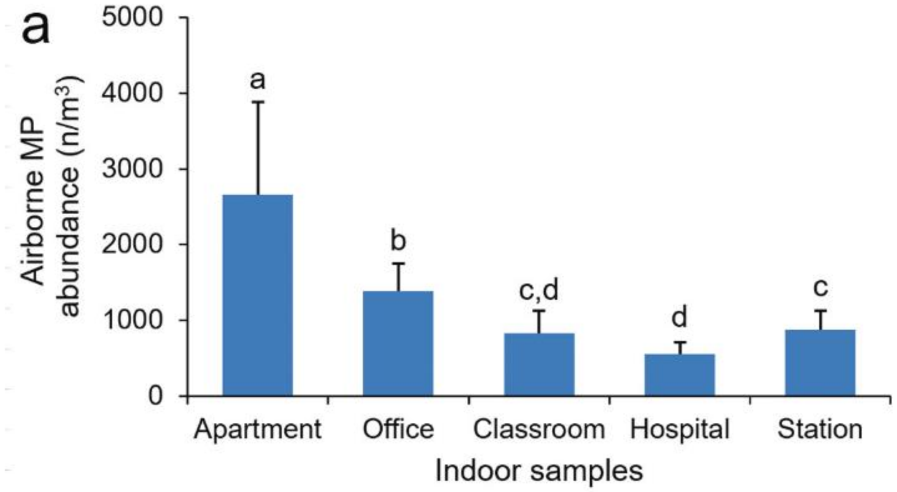
[a] Key Laboratory of Watershed Sciences and Health of Zhejiang Province, School of Public Health and Management, Wenzhou Medical University, Wenzhou 325035, China

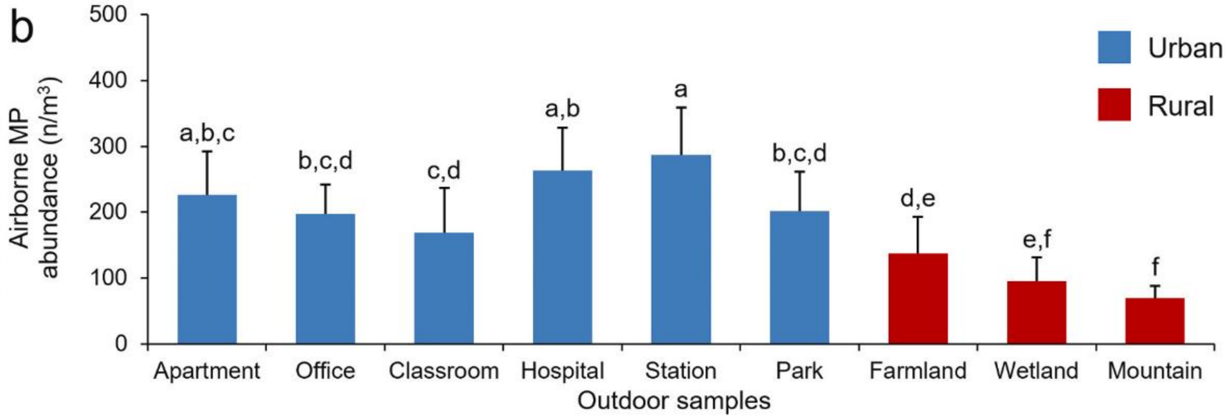
[b] School of Life and Environmental Science, National & Local Joint Engineering Research Center for Ecological Treatment Technology of Urban Water Pollution, Wenzhou University, Wenzhou 325035, China

[c] Laboratory of Marine Ecosystem and Biogeochemistry, Second Institute of Oceanography SOA, Hangzhou 310012, China

[d] Department of Land, Air and Water Resources, University of California Davis, CA 95616, USA







J Hazard Mater. 2021 Sep 5;417:126007.

Summary of airborne MP characteristics compiled from previous studies.

Study area	Local environment	Abundance (n/m^3)	Size range	Dominant size	Dominant shape	Dominant polymer composition	References
Paris, France	Indoor	1–60	50–3250 μm	50–450 μm: > 80%	Fiber	PP	Dris et al. (2017)
	Outdoor	0.3–1.5	50–1650 μm		Fiber		
Aarhus, Denmark	Indoor	9.3 ± 5.8	11–370 μm	Median: 68 μm for fragment and 237 μm for fiber	Fiber: 13% Fragment: 87%	Polyester, PE, Nylon	Vianello et al. (2019)
West Pacific Ocean	Outdoor	0–1.37	16–2087 μm	< 500 μm: > 50%	Fiber: 60% Fragment: 31%	PET: 57% PE: 10%	Liu et al. (2019b)
Shanghai, China	Outdoor	1.42 ± 1.42	23–9555 μm	23–500 μm: > 50%	Fiber: 67% Fragment: 30%	PET, PE, PES, PAN, PAA, Rayon	Liu et al. (2019a)
Surabaya, Indonesia	Outdoor	55.93–174.97	< 500–5000 μm	< 1500 μm: ~48%	Fiber	Cellophane, PE, PET	Syafei et al. (2019)
Beijing, China	Outdoor	4500–7200	5–200 μm	< 20 μm: > 80%	Only fibers studied	N/A	Li et al. (2020)
Wenzhou, China	Indoor	1583.3 ± 1180.6	5–4665 μm	< 30 μm: 60.4% 30–100 μm: 28.5%	Fiber: 10.4% Fragment: 89.6%	Polyester, PA, PP	This study
	Outdoor	188.7 ± 84.8	5–1794 μm	< 30 μm: 65.1% 30–100 μm: 29.4%	Fiber: 5.8% Fragment: 94.2%	PE, PS, Polyester	

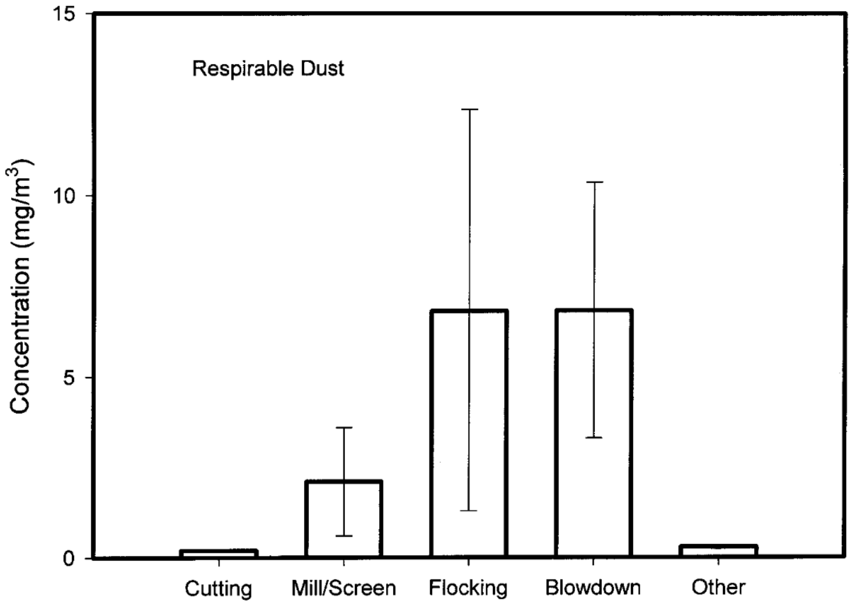
J Hazard Mater. 2021 Sep 5;417:126007.

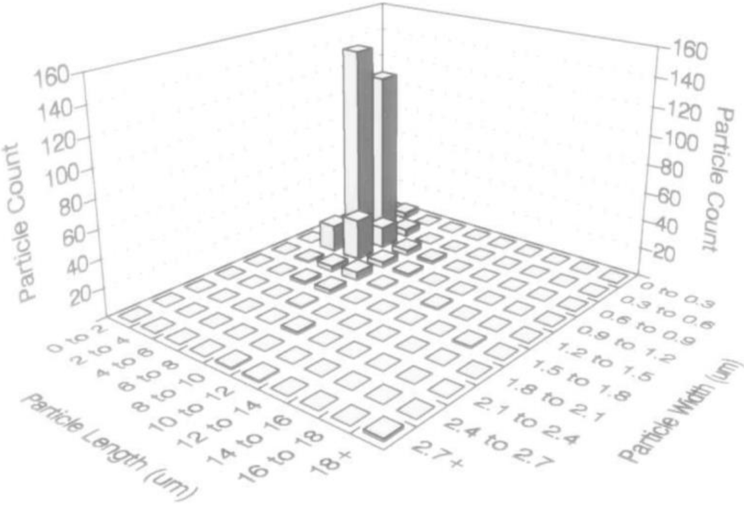
Little data on hazardous effect of NMP in human

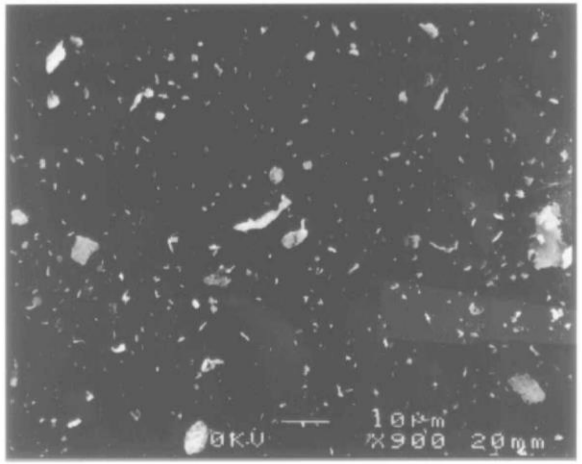
Observations from epidemiology

Flock worker's lung



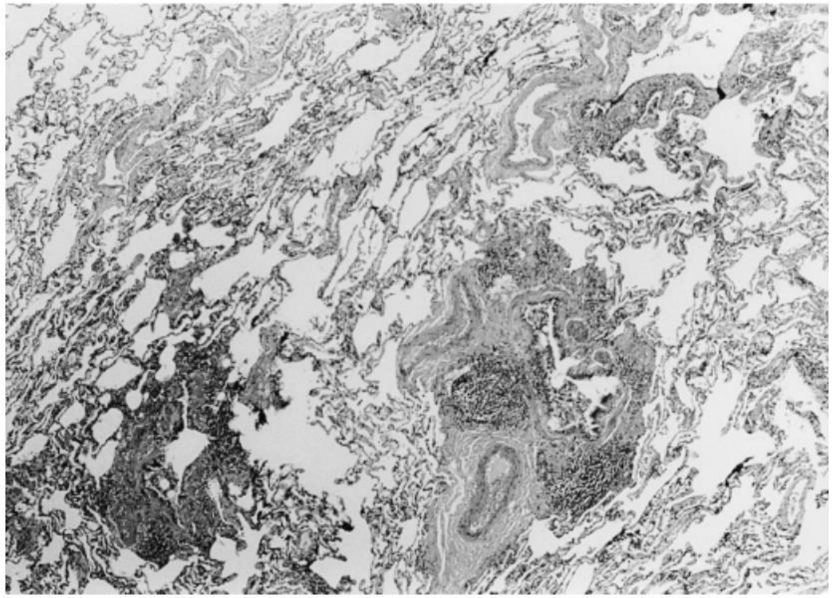





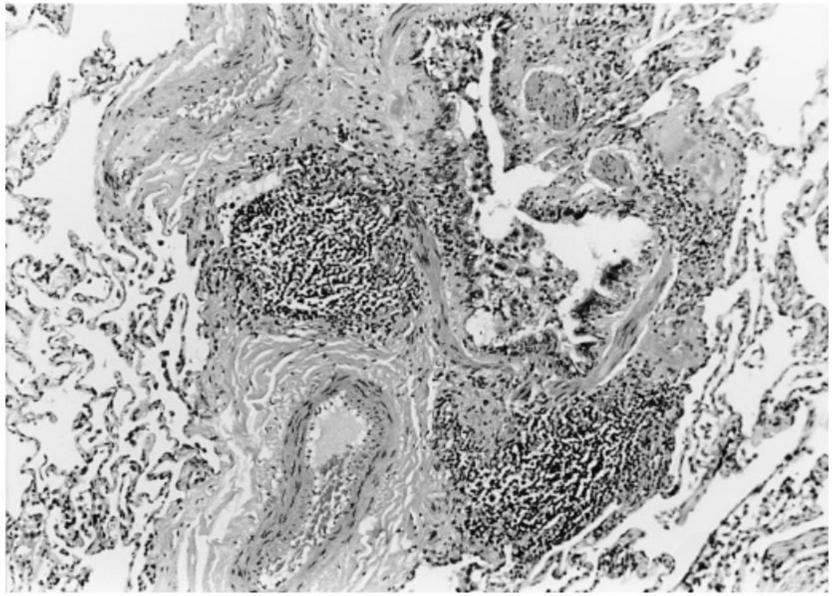


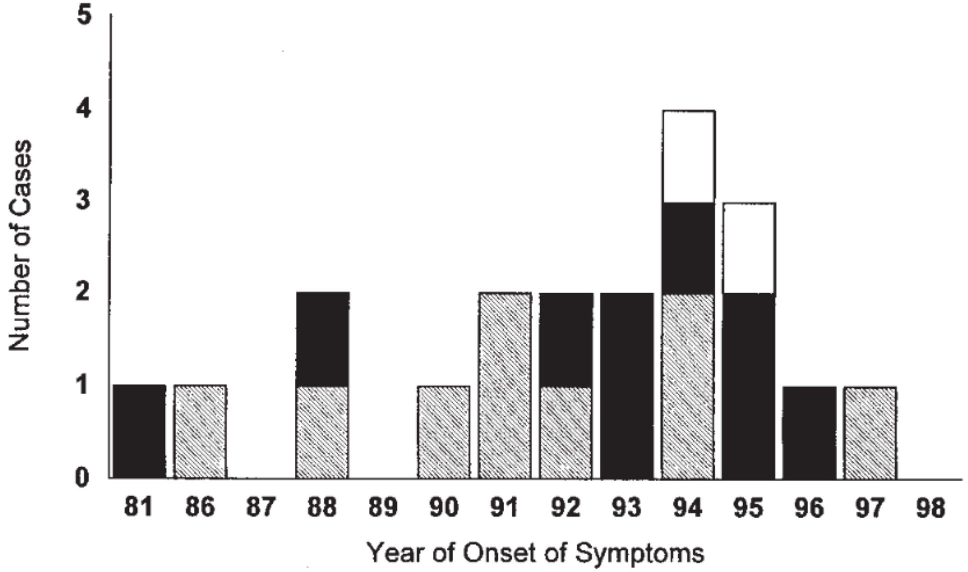
J Toxicol Environ Health A. 1999 May 14;57(1):1-23.

A



B





Am J Respir Crit Care Med. 1999 Jun;159(6):2003-8.

A

B

Figure 4. (*A*) Chest radiograph and (*B*) CT scan results for one of the cases of interstitial lung disease associated with nylon flock processing. The diffuse interstitial involvement is predominantly in a peripheral pattern.

Eur Respir J 2002; 20: 1610–1612
DOI: 10.1183/09031936.02.00030102

European Respiratory Journal
ISSN 0903-1936

CASE STUDY

Polyethylene flock-associated interstitial lung disease in a Spanish female

E. Barroso*, M.D. Ibañez[#], F.I. Aranda[¶], S. Romero*

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 50:274–284 (2007)

Rayon Flock: A New Cause of Respiratory Morbidity in a Card Processing Plant

Vinicius C.S. Antao, MD, MSc, PhD,* Chris A. Piacitelli, CIH, William E. Miller, MS, Germania A. Pinheiro, MD, MSc, PhD, and Kathleen Kreiss, MD

Eur Respir J 2005; 25: 110–117
DOI: 10.1183/09031936.04.00138403

The respiratory effects of occupational polypropylene flock exposure

S. Atis*, B. Tutluoglu[#], E. Levent[¶], C. Ozturk[+], A. Tunaci[§], K. Sahin[¶], A. Saral[ƒ], I. Oktay[¶], A. Kanik and B. Nemery[##]**

Am J Ind Med. 2007 Apr;50(4):274-84. doi: 10.1002/ajim.20440.
Eur Respir J. 2002 Dec;20(6):1610-2.
Eur Respir J. 2005 Jan;25(1):110-7.

Association with lung cancer

Original Articles

A Retrospective Cohort Study of Lung Cancer Incidence in Nylon Flock Workers, 1998–2008

David G. Kern, Eli Kern, Robert S. Crausman & Richard W. Clapp

Pages 345-351 | Published online: 19 Jul 2013

Download citation

ORIGINAL ARTICLE

Cancer mortality in a synthetic spinning plant in Besançon, France

M Hours, J Févotte, S Lafont, A Bergeret

Occup Environ Med 2007;**64**:575–581. doi: 10.1136/oem.2006.028282

Original article

Lung cancer and occupational exposures other than cotton dust and endotoxin among women textile workers in Shanghai, China

H Checkoway,[1,2] R M Ray,[3] J I Lundin,[1] G Astrakianakis,[4] N S Seixas,[1] J E Camp,[1] K J Wernli,[5] E D Fitzgibbons,[5] W Li,[2,3] Z Feng,[3] D L Gao,[6] D B Thomas[2,3]

Lung cancer incidence : 5 vs 1.61
(IRR 3.1, 95%CI 1.01-7.23)

Mortality from lung cancer

- "hot -line fitters"
  (RR = 2.13; 1.06 to 4.29)
- "fibre-drawing workers"
  (RR = 1.83;1.09 to 3.07)

No associations between lung cancer with wool, silk or synthetic fibre dusts, or with most other agents

Occup Environ Med. 2007 Sep;64(9):575-81.
Occup Environ Med. 2011 Jun;68(6):425-9.
Int J Occup Environ Health. 2011 Oct-Dec;17(4):345-51.

Thorax (1975), **30,** 204.

Respiratory disease caused by synthetic fibres: a new occupational disease[1]

J. CORTEZ PIMENTEL, RAMIRO AVILA,
and A. GALVÃO LOURENÇO

IANT (Department of Pathology of Sanatorio D. Carlos I), Institute of Pathology and Department of Chest Diseases, Lisbon University Faculty of Medicine

Pimentel, J. C., Avila, R., and Lourenço, A. G. (1975). *Thorax*, **30,** 204–219. **Respiratory disease caused by synthetic fibres: a new occupational disease.** Seven patients exposed to

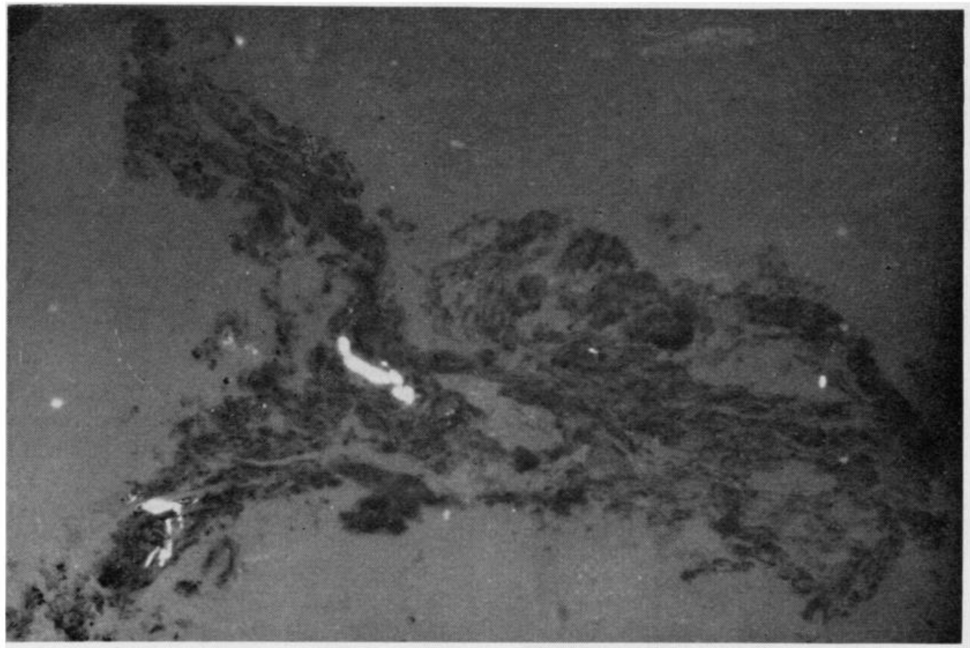


FIG. 11. *Case* 6. *View of the lung lesions. Numerous inclusions of polyester fibres* (*polarized light*) (*H and E* ×75).

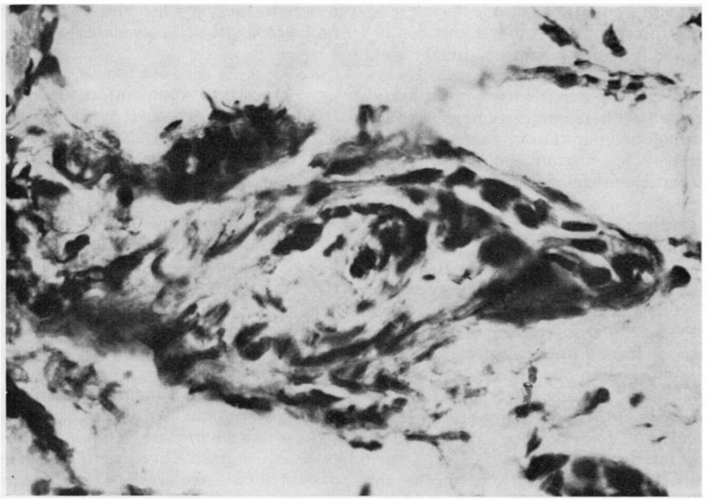


FIG. 1. *Case* 1. *Detail of granuloma of the interalveolar septa. Cellular proliferation made up of histiocytes and fibroblasts. Note the presence of slits where the Orlon fibres lay* (*H and E* ×550).

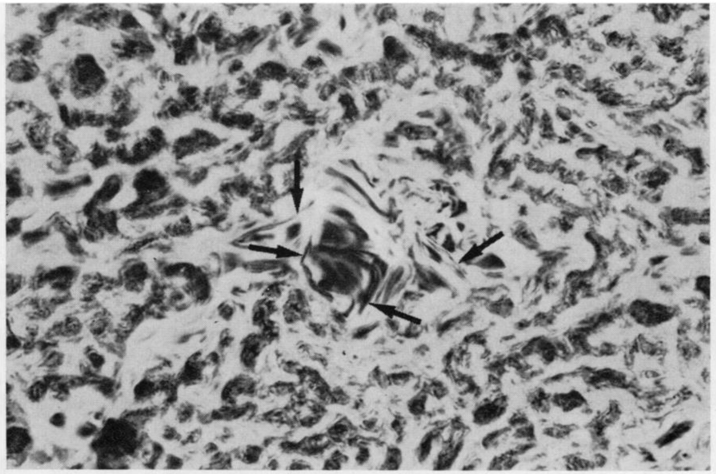


FIG. 2. *Case* 1. *Detail of a granuloma of the interalveolar septa* (*phase contrast*). *Arrows show Orlon fibres.* (*H and E* ×500).

Thorax. 1975 Apr;30(2):204-19.

Eur Respir J 2009; 34: 559–567
DOI: 10.1183/09031936.00178308

Exposure to nanoparticles is related to pleural effusion, pulmonary fibrosis and granuloma

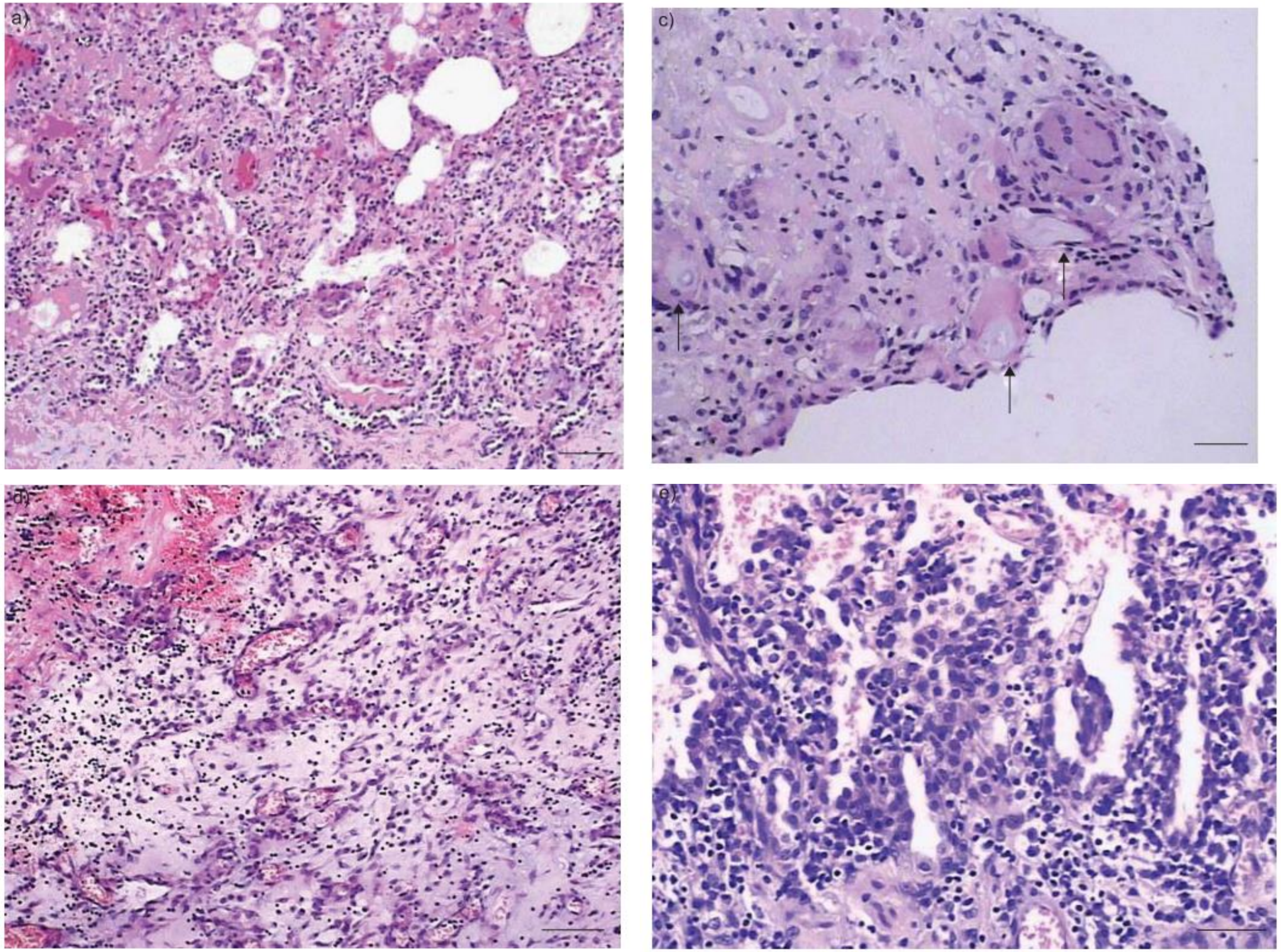
Y. Song*, X. Li# and X. Du*

- 7 young female patients, working in the same department in a print plant, were admitted to our hospital (Beijing Chaoyang Hospital, Beijing, China).

- All had
  - same symptoms : shortness of breath
  - same clinical findings : pleural effusion and pericardial effusion.

- Polyacrylate, consisting of nanoparticles, was confirmed in the workplace.

Eur Respir J. 2009 Sep;34(3):559-67



Eur Respir J. 2009 Sep;34(3):559-67

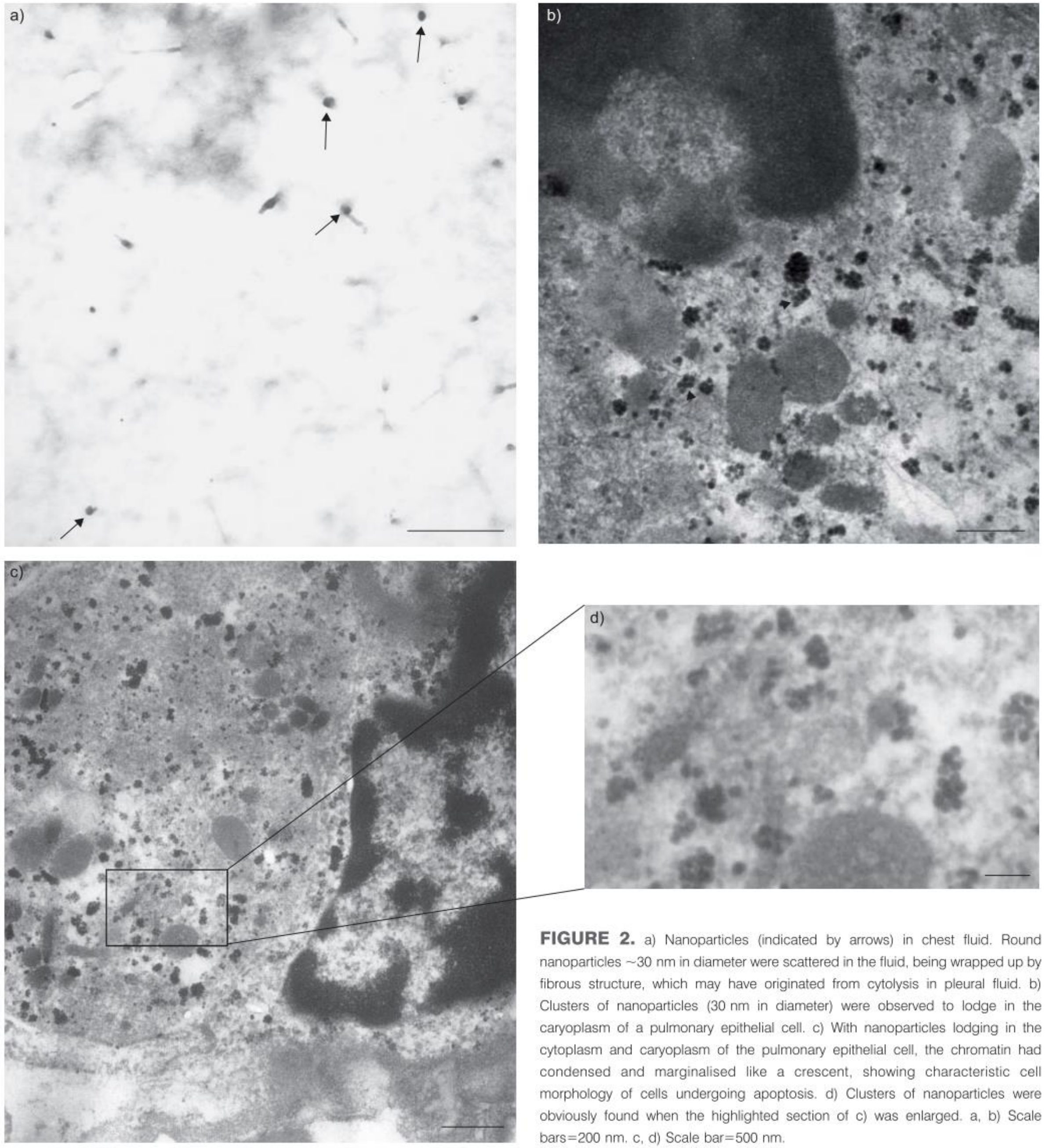


FIGURE 2. a) Nanoparticles (indicated by arrows) in chest fluid. Round nanoparticles ~30 nm in diameter were scattered in the fluid, being wrapped up by fibrous structure, which may have originated from cytolysis in pleural fluid. b) Clusters of nanoparticles (30 nm in diameter) were observed to lodge in the caryoplasm of a pulmonary epithelial cell. c) With nanoparticles lodging in the cytoplasm and caryoplasm of the pulmonary epithelial cell, the chromatin had condensed and marginalised like a crescent, showing characteristic cell morphology of cells undergoing apoptosis. d) Clusters of nanoparticles were obviously found when the highlighted section of c) was enlarged. a, b) Scale bars=200 nm. c, d) Scale bar=500 nm.

Eur Respir J. 2009 Sep;34(3):559-67

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Research Paper

Presence of airborne microplastics in human lung tissue

Luís Fernando Amato-Lourenço[a,b,*], Regiani Carvalho-Oliveira[a], Gabriel Ribeiro Júnior[a], Luciana dos Santos Galvão[c], Rômulo Augusto Ando[d], Thais Mauad[a,b]

- 20 Non-smokers → Autopsy
- Lived in Sao Paulo for more than 10 years

Table 1
Demographic information of the 20 decedents. *Histological analysis not performed.

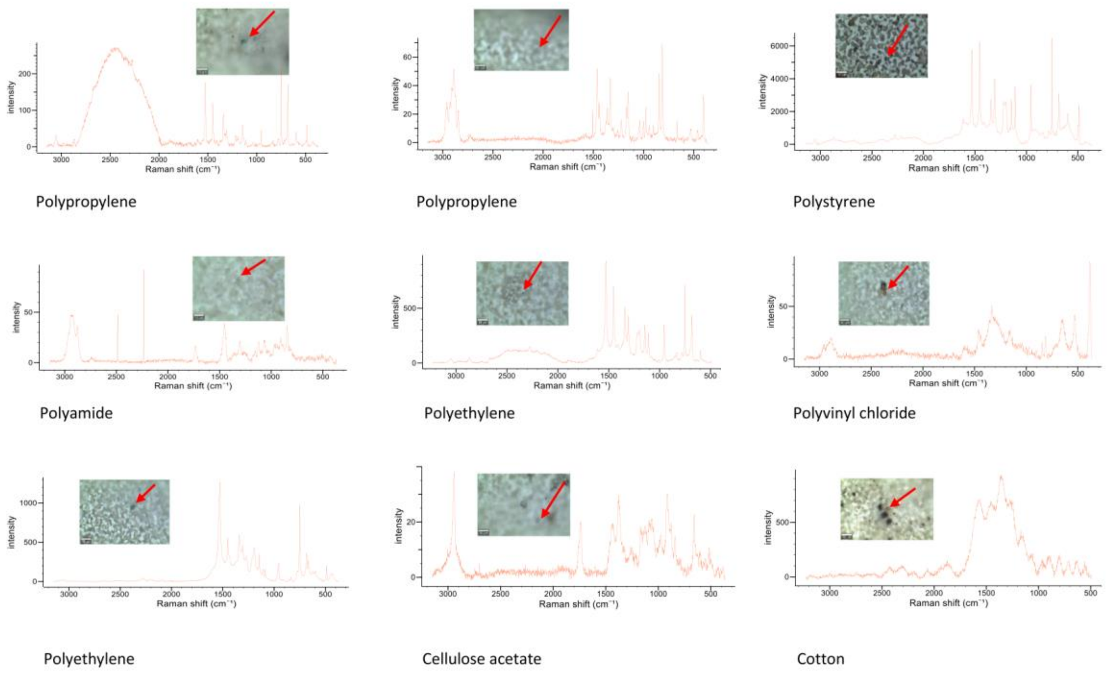
Case	Demographic data			Underlying diseases	Cause of death	Histological findings	Pulmonary tissue weight (g)	Died at hospital? (yes/no)
	Age at death	Gender	Occupation					
1	55	M	Bricklayer assistant	Diabetes, systemic arterial hypertension, hypertensive cardiomyopathy, alcoholism	Pulmonary oedema	*	3.04	No
2	89	M	Salesman	Systemic arterial hypertension, malignant prostate cancer	Pulmonary thromboembolism	Pulmonary thromboembolism, senile emphysema, pneumonia	2.06	No
3	79	M	Construction supervisor	Stroke, prostate cancer	Massive pulmonary thromboembolism	*	3.56	Yes
4	74	M	Accountant	Diabetes, systemic arterial hypertension, stroke	Aspiration pneumonia	Bacterial pneumonia	4.23	No
5	86	F	Housewife	Ruptured brain aneurysm	Cerebral haemorrhage	Senile emphysema	2.10	Yes
6	59	M	Serigrapher	Old myocardial infarction	Acute myocardial infarction	Pulmonary oedema	2.64	No
7	79	M	Bricklayer assistant	Systemic arterial hypertension, stroke	Pulmonary thromboembolism	Pulmonary thromboembolism, bronchopneumonia	3.50	Yes
8	78	F	Housewife	Systemic arterial hypertension	Bronchopneumonia	Bronchopneumonia	2.23	No
9	75	F	Quality inspector	Heart disease, chronic lung disease, cardiac failure	Hydropericardium	Emphysema, chronic bronchitis	2.83	No
10	79	F	Housekeeper	Systemic arterial hypertension, atherosclerotic hypertensive heart disease, stroke	Pulmonary oedema	Pulmonary oedema	3.89	No
11	48	M	Security guard	Diabetes, systemic arterial hypertension, heart disease,	Pulmonary oedema	Chronic passive congestion of the lung	5.42	No
12	94	F	Housewife	Dementia	Bilateral bronchopneumonia	*	2.57	Yes
13	74	F	Librarian	Systemic arterial hypertension, ruptured abdominal aortic aneurysm	Hypovolemic shock	Normal histology	3.86	No
14	90	F	Teacher	Systemic arterial hypertension, heart disease	Pulmonary thromboembolism	Pulmonary oedema	4.42	Yes
15	67	F	Farmer	Systemic arterial hypertension, heart disease, stroke, alcoholism,	Abdominal haemorrhage	Pulmonary oedema	3.50	Yes
16	60	F	Housekeeper	Diabetes, systemic arterial hypertension, acute myeloid leukaemia, stroke	Pulmonary oedema	Pulmonary oedema	2.04	No
17	79	F	Masseuse	Diabetes, systemic arterial hypertension, cerebral aneurysm	Subarachnoid haemorrhage	Normal histology	2.94	No
18	88	F	Housekeeper	Diabetes, stroke, systemic arterial hypertension, generalized atherosclerosis	Cerebral ischemic infarction	Bronchopneumonia	3.53	No
19	89	F	Cooker	Systemic arterial hypertension, stroke	Pulmonary thromboembolism	Pulmonary thromboembolism	4.45	No
20	78	F	Housewife	Systemic arterial hypertension, stroke, focal necrosis of the small intestine	Acute peritonitis	Pulmonary oedema	2.71	No

Observations from epidemiology

J Hazard Mater. 2021 Aug 15;416:126124.

Table 2
Morphology and chemical characterization of the identified particles/fibres.

Decedent	Particle/ fibre	Size (μm)	Polymer matrix	Colour
3	Fibre	16.80	Polypropylene	White/grey
3	Particle	2.82	Cotton	Brown
3	Particle	4.25	Polypropylene	White/grey
4	Particle	5.42	Cotton	Beige
4	Particle	4.20	Polyethylene	Transparent
4	Particle	2.84	Cotton	White
6	Fibre	8.93	Cellulose acetate	Grey
6	Particle	4.30	Polyvinyl chloride	Black
8	Fibre	11.08	Polypropylene	Blue
8	Fibre	8.12	Polypropylene	Blue
8	Particle	4.30	Polyethylene	Transparent
9	Particle	1.98	Cotton	Yellow
9	Particle	4.29	Polyethylene-co-polypropylene	Grey
9	Particle	3.49	Cotton	Brown
10	Particle	3.34	Polypropylene	White/grey
10	Particle	3.55	Polypropylene	White/grey
10	Particle	4.42	Polypropylene	White/grey
10	Particle	5.30	Polypropylene	White/grey
11	Particle	2.40	Polyurethane	Beige
11	Particle	3.47	Polystyrene	Blue
11	Particle	4.12	Cotton	Grey
12	Particle	5.40	Polyethylene	Grey
12	Particle	4.43	Polystyrene-co-polyvinyl chloride	Grey
12	Particle	4.05	Polyethylene	Grey
12	Particle	3.07	Polypropylene	Grey
12	Particle	3.55	Polypropylene	White/grey
12	Particle	3.96	Polypropylene	White/grey
13	Particle	1.60	Polyethylene	Blue
16	Particle	3.26	Polyethylene	Blue
16	Particle	3.54	Polypropylene	Green
16	Particle	5.20	Polyethylene	Blue
16	Particle	3.95	Polyethylene	Grey
17	Particle	4.26	Polyvinyl chloride	Orange
19	Particle	4.52	Cellulose acetate	Grey
20	Particle	2.69	Polyethylene	Grey
20	Particle	5.56	Polypropylene	White/grey
20	Particle	3.85	Polyamide	White/grey



- 31 synthetic polymer particles/fibers were observed in 13/20 autopsied decedents
- The mean particle size was 3.92 μm,
- The mean fiber length was 11.23 μm

- Polypropylene (35.1%) > polyethylene (24.3%) > cotton (16.2)

J Hazard Mater. 2021 Aug 15;416:126124.

Science of the Total Environment 831 (2022) 154907

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Detection of microplastics in human lung tissue using μFTIR spectroscopy

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- Excess human lung tissue was collected from thoracic surgical procedures at Castle Hill Hospital

- A total of 39 MPs were identified within 11 of the 13 human lung tissue samples.

ID	Sex	Lung region	Tissue (g)	MP total	MP polymer	Length, width (μm)	Shape	MP/g[a]	MP/g[b]	MP/g[c]
1.1	M	R, Low	2.02	8	PET	88, 10	Fibre	3.96	2.97	1.94 based on PP only
					PP	55, 28	Fragment			
					PP	39,18	Fragment			
					PP	420, 9	Fibre			
					PP	27, 10	Fragment			
					PS	89, 71	Fragment			
					PTFE	100, 29	Fibre			
					PTFE	92, 88	Film			
1.2		R, Up	0.79	2	PP	109, 18	Fibre	2.53	0.00	
					TPE	66, 19	Fibre			
2.1	M	R, Low	0.80	3	PP	40, 22	Fragment	3.75	1.25	
					PP	144, 65	Fragment			
					PTFE	26, 20	Fragment			
2.2		L, Low	0.84	3	PS	14, 14	Fragment	3.57	1.19	
					PTFE	96, 5	Fibre			
					Resin	19, 13	Fragment			
3.1	M	R, Up	13.33	5	PE	224, 9	Fibre	0.38	0.23	
					PE	29, 17	Fragment			
					PET	202, 6	Fibre			
					PP	101, 17	Fibre			
					SEBS	83, 18	Film			
4.1	M	R, Up	1.53	2	PS	60, 44	Fragment	1.31	0.65	
					Resin	12, 9	Fragment			
5.1	F	L, Lin	1.37	0	none	none		0.00	0.00	
6.1	M	R, Mid	3.98	2	PE	17, 10	Fragment	0.50	0.25	
					Resin	20, 15	Fragment			
7.1	F	R, Up	8.29	1	PES	40, 22	Fragment	0.12	0.00	
8.1	F	L, Low	5.90	7	PAN	1112, 9	Fibre	1.19	1.19	
					PE	28, 20	Fragment			
					PET	443, 13	Fibre			
					PET	452, 12	Fibre			
					PP	160, 46	Fragment			
					Resin	101, 9	Fibre			
					Resin	261, 22	Fibre			
9.1	M	R, Mid	6.84	5	PET	897, 10	Fibre	0.73	0.73	
					PET	2475, 12	Fibre			
					PMMA	96, 76	Fragment			
					PUR	155, 16	Fibre			
					Resin	14, 4	Fibre			
10.1	F	R, Up	2.12	1	PET	275, 12	Fibre	0.47	0.47	
11.1	F	R, Up	7.60	0	none	none		0.00	0.00	
Mean ± SD								1.42 ± 1.5	0.69 ± 0.84	

Sci Total Environ. 2022 Jul 20;831:154907

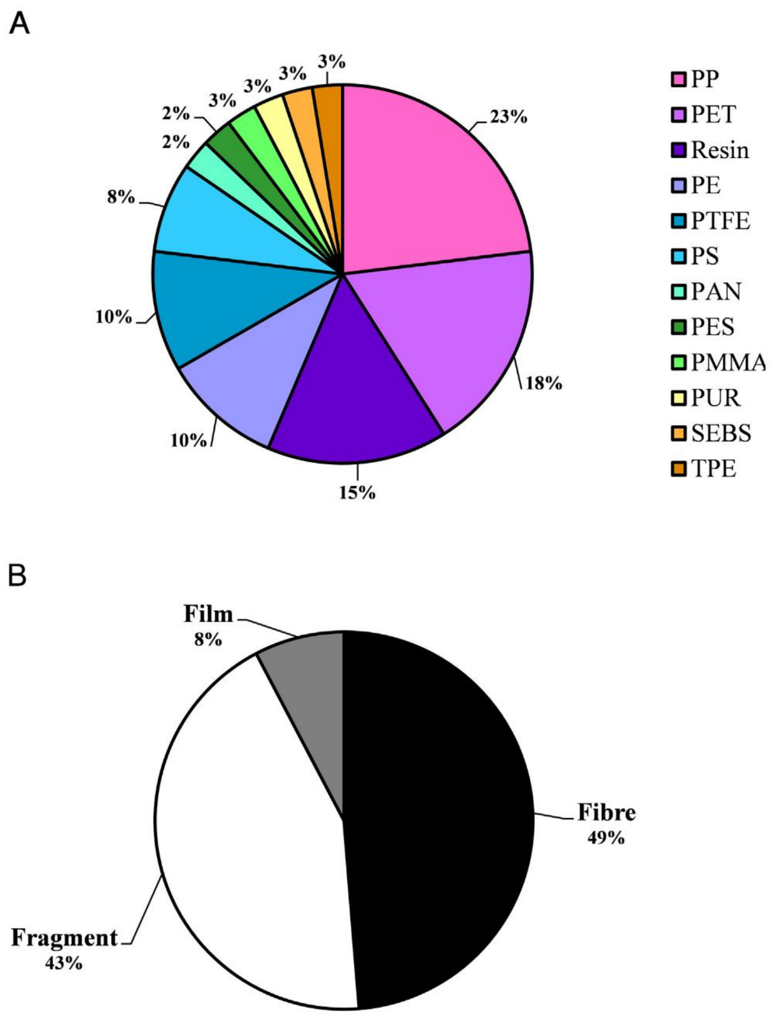

Fig. 1. Polymer types (A) and shapes (B) of the MPs identified within lung tissue samples.

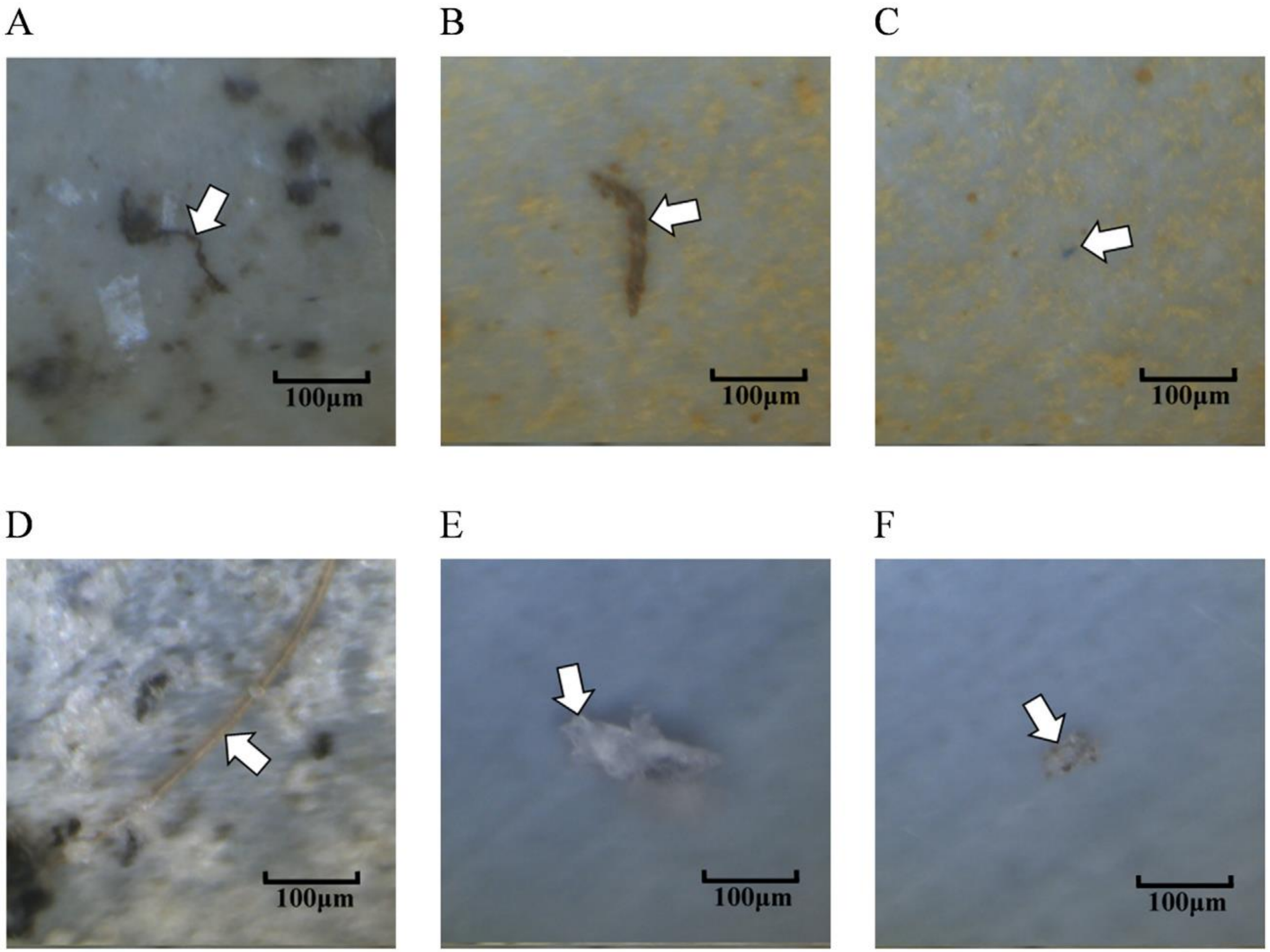

Fig. 2. Images of MPs identified from human lung tissue samples. A, B, C and D = (A = PET) (B = PUR) (C = Resin) (D = PAN). E and F = MPs identified within blanks. (E = PS) (F = PP). Corresponding spectra included in Fig. S2.

Sci Total Environ. 2022 Jul 20;831:154907

Environment International 163 (2022) 107199

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ELSEVIER

Full length article

Discovery and quantification of plastic particle pollution in human blood

Heather A. Leslie[a], Martin J.M. van Velzen[a], Sicco H. Brandsma[a], A. Dick Vethaak[a,b], Juan J. Garcia-Vallejo[c], Marja H. Lamoree[a,*]

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- Measured plastic particles in human whole blood from 22 healthy volunteers.

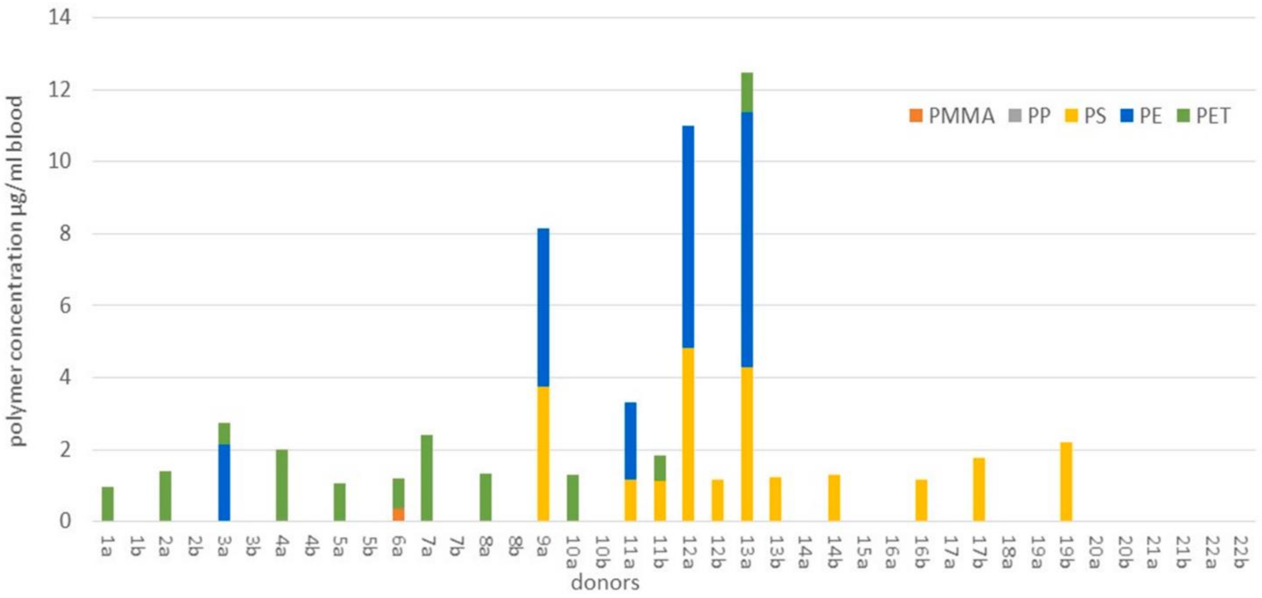

Fig. 1. Concentrations of plastic particles by polymer type in whole blood samples of 22 donors (duplicates a and b, except for No. 6, 9, 15 and 18). All values >LOQ.

Environ Int. 2022 May;163:107199.

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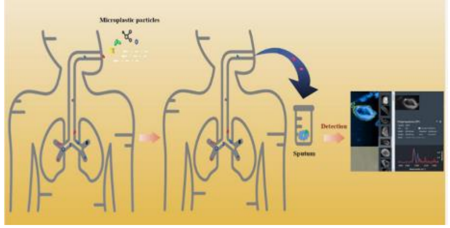

Detection and Analysis of Microplastics in Human Sputum

Shumin Huang,[▽] Xiaoxin Huang,[▽] Ran Bi, Qiuxia Guo, Xiaolin Yu, Qinghui Zeng, Ziyu Huang, Tianming Liu, Haisheng Wu, Yuliang Chen, Jialong Xu, Yinge Wu,[*,○] and Pi Guo[*,○]

- 22 sputum specimen → 32% detected microplastic
- the size range : 20−500 μm. (median: 75.43 μm; interquartile range: 44.67−210.64 μm)
- 21 types of microplastics were identified,
    - polyurethane >polyester>chlorinated polyethylene> alkyd varnish

Table 3. Comparisons of the Number of Microplastic Types According to Individual Characteristics of Participants Involved (Unit: particles/10 mL)[a,b]

characteristics	category	median	IQR	*P*-value
sex	female	6	1	0.093
	male	7	3	
age (years)	<60	6.5	1	0.439
	≥60	6	3.5	
occupational exposure	no	6	2.5	0.908
	yes	6.5	2.5	
alcohol drinker	no	6	3.5	0.362
	yes	7	0.5	
individual smoking status	no	5.5	2.5	0.022
	yes	7	3	
invasive tracheal examination	no	6	1.5	0.706
	yes	7	8	
having buildings near residential addresses or not	no	6	3	0.609
	yes	6.5	1.25	
$PM_{2.5}$ ≥ mean (25.34 $\mu g/m^3$)	no	6	3	0.663
	yes	6	1.5	
having COPD	no	5	1.75	0.531
	yes	6	3.75	
having bronchiectasis	no	5	2	0.433
	yes	5	2	
having COPD and bronchiectasis	no	5	1.75	0.531
	yes	6	3.75	
wearing of face masks within 2 weeks	almost no	7	4	0.867
	occasionally	6	1.5	
	sometimes	6.5	5.5	
	often	6	2	

[a]IQR: interquartile range. COPD: chronic obstructive pulmonary disease. [b]Statistically significant differences between groups were tested using the Mann−Whitney *U*-test ($P < 0.05$).

Environ Sci Technol. 2022 Feb 15;56(4):2476-2486.

In vitro studies

Journal of Hazardous Materials 385 (2020) 121575

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Journal of Hazardous Materials

journal homepage: www.elsevier.com/locate/jhazmat

Polystyrene microplastic particles: In vitro pulmonary toxicity assessment

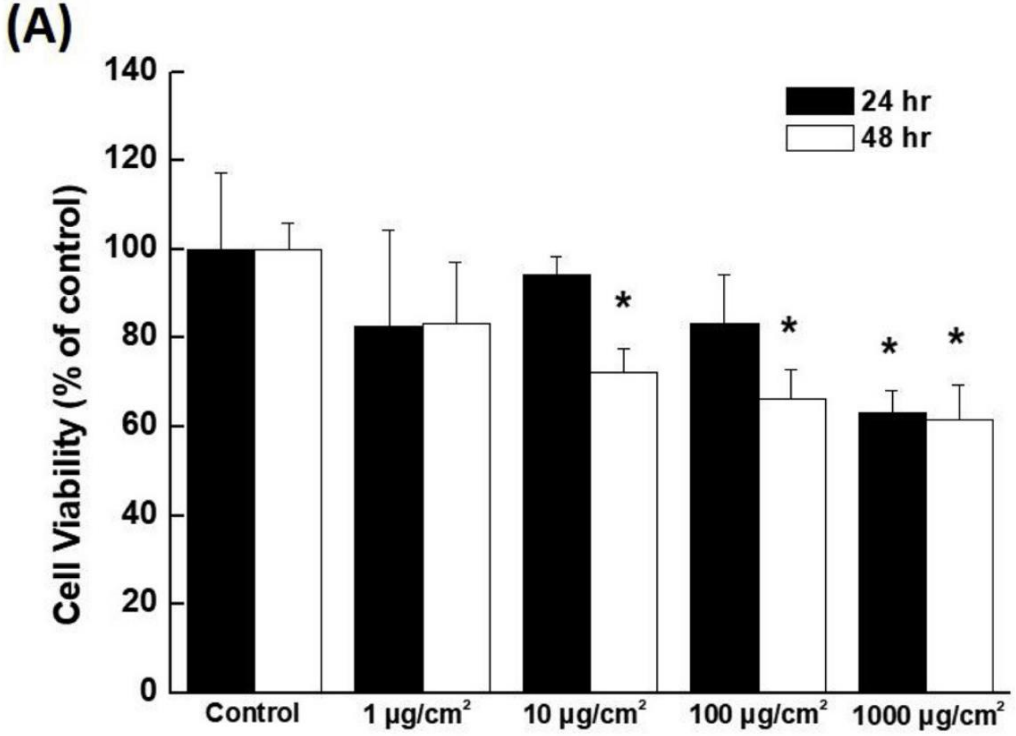
Cheng-Di Dong[a], Chiu-Wen Chen[a], Yi-Chun Chen[b], Hung-Hsiang Chen[b], Jin-Sun Lee[a,*], Chia-Hua Lin[b,*]

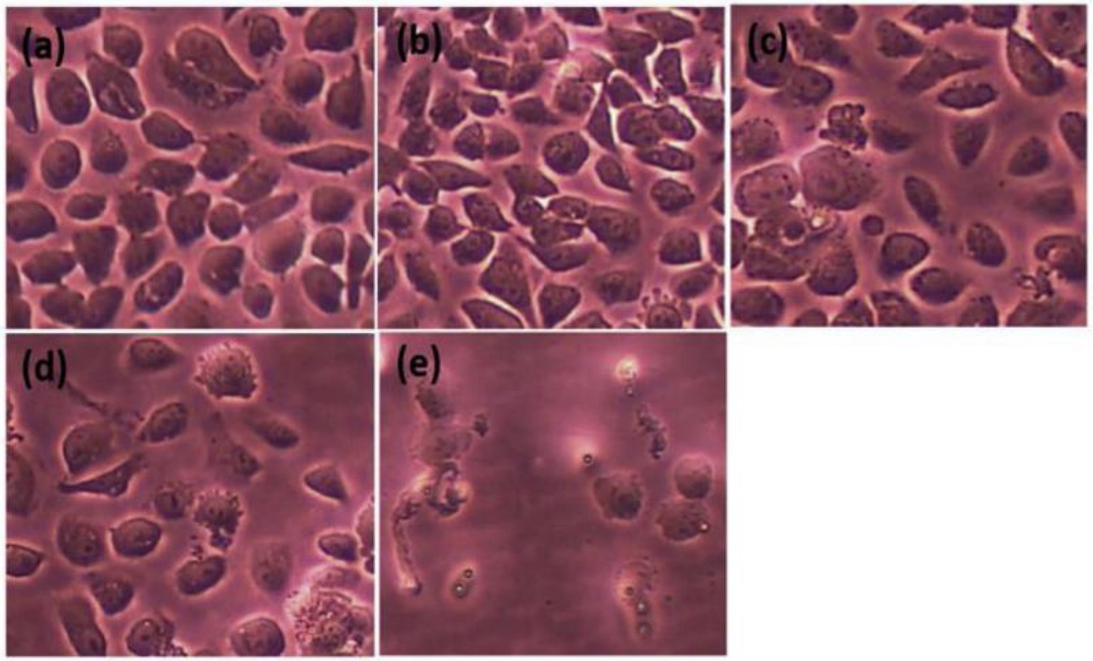
[a] *Department of Marine Environmental Engineering, National Kaohsiung University of Science and Technology, Kaohsiung, 81157, Taiwan*
[b] *Department of Biotechnology, National Formosa University, Yunlin, 63208, Taiwan*

- BEAS-2B (Human lung epithelial cell line) + PS-MP (polystyrene-microplastic)

J Hazard Mater. 2020 Mar 5;385:121575.

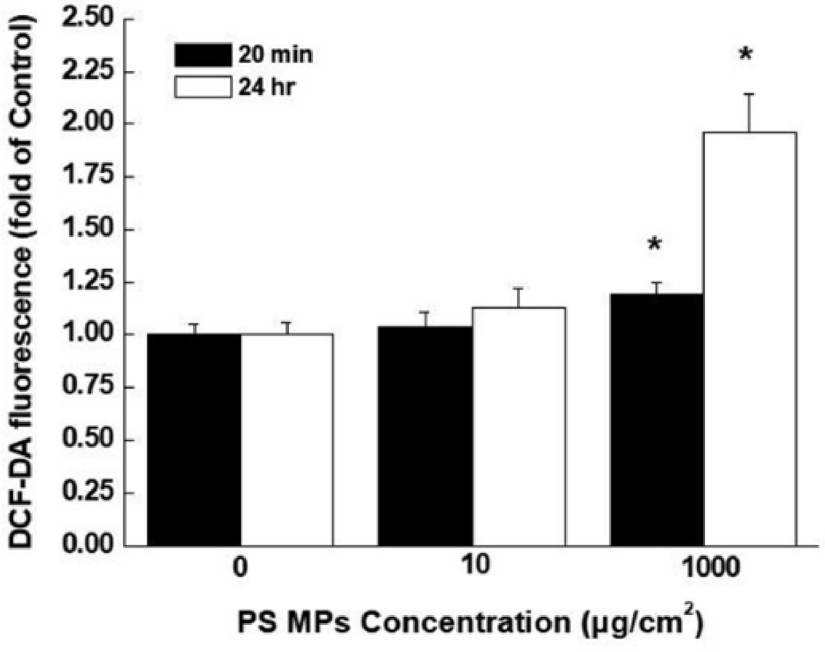
Cell viability

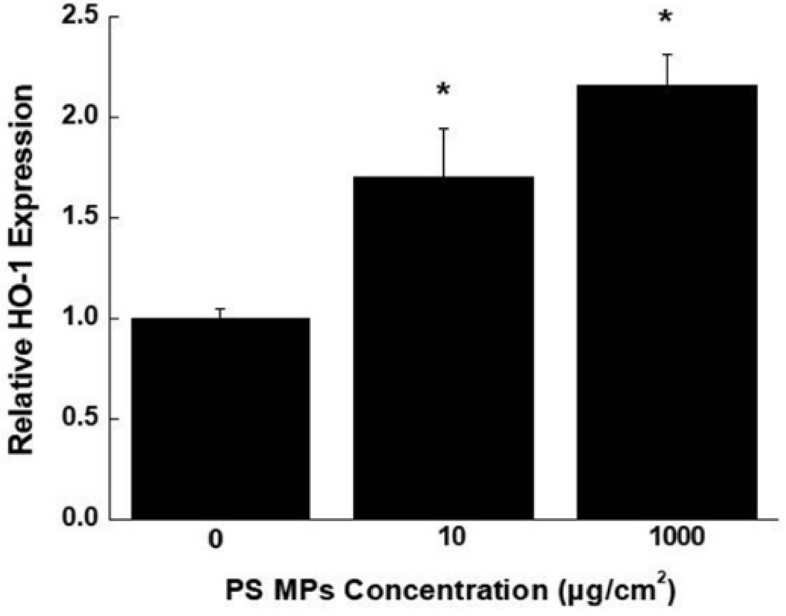


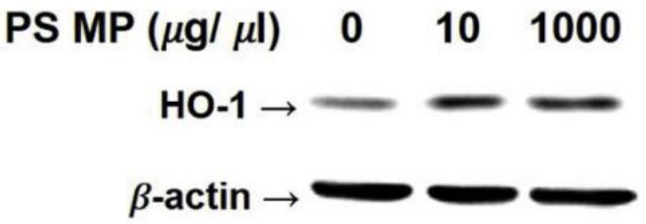


J Hazard Mater. 2020 Mar 5;385:121575.

Oxidative adverse response : HO-1 protein







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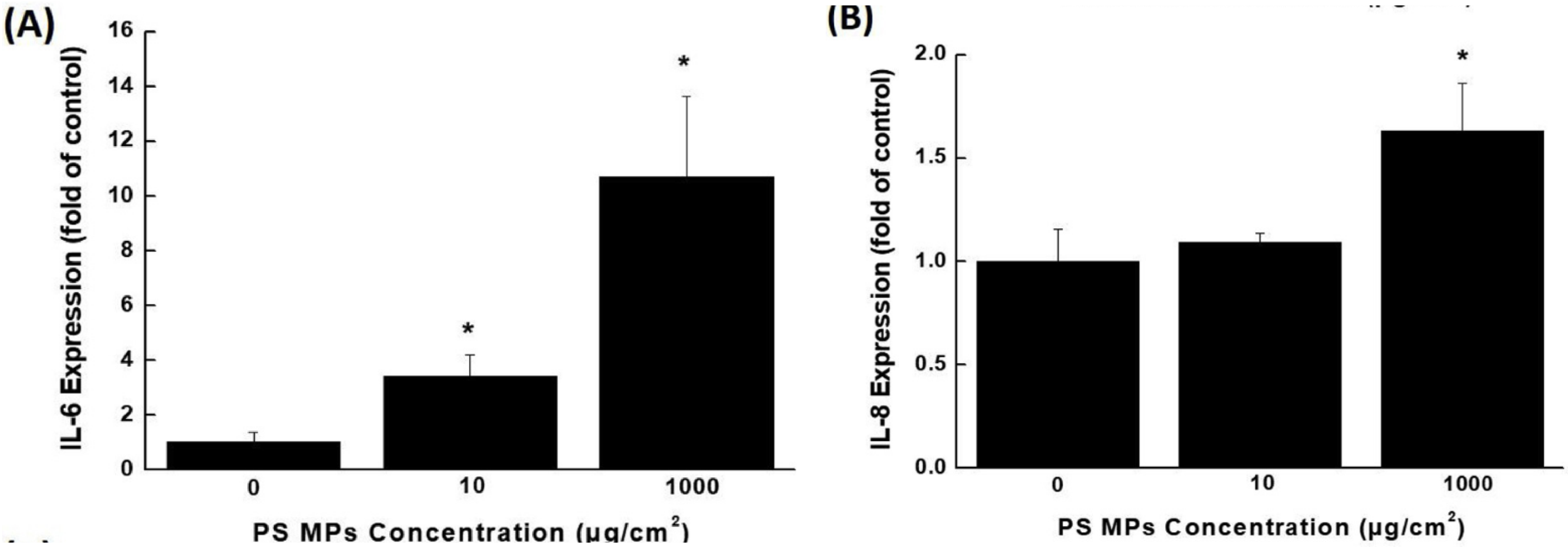
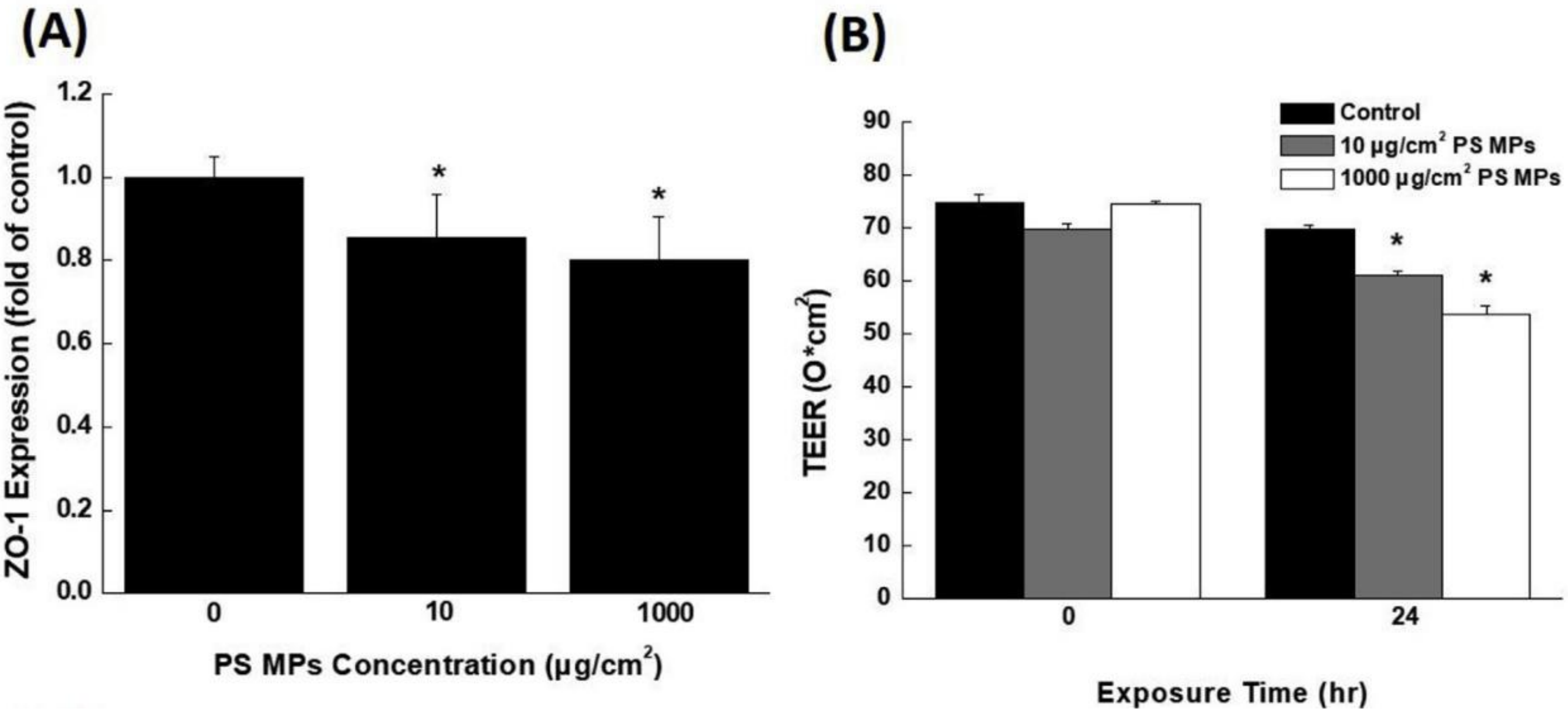
Pro-inflammatory cytokines



J Hazard Mater. 2020 Mar 5;385:121575.

Epithelial cell barrier integrity biomarker



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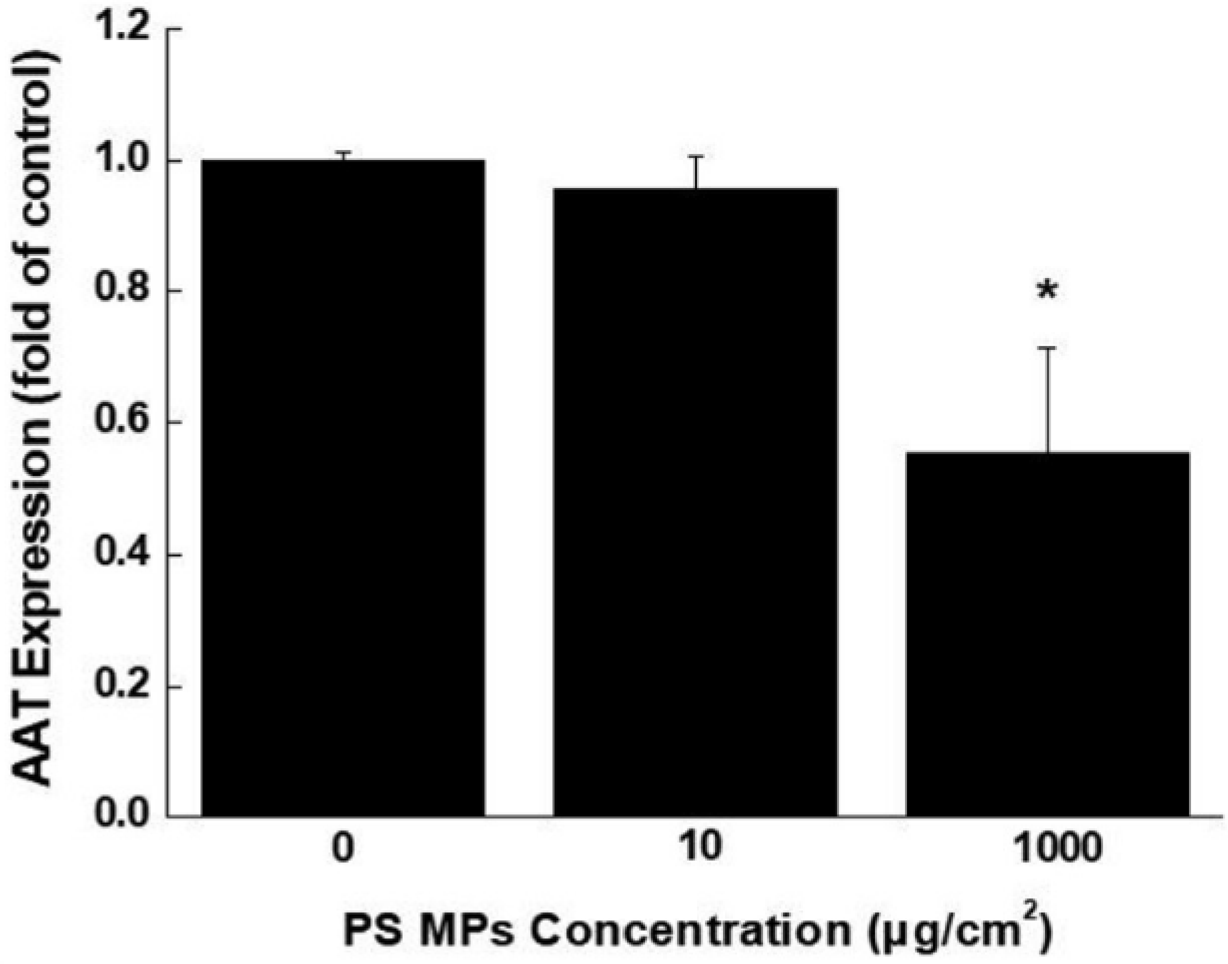
Predictive biomarker for COPD



J Hazard Mater. 2020 Mar 5;385:121575.

In vivo studies

Chemosphere 262 (2021) 128330

Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

Inhalation toxicity of polystyrene micro(nano)plastics using modified OECD TG 412

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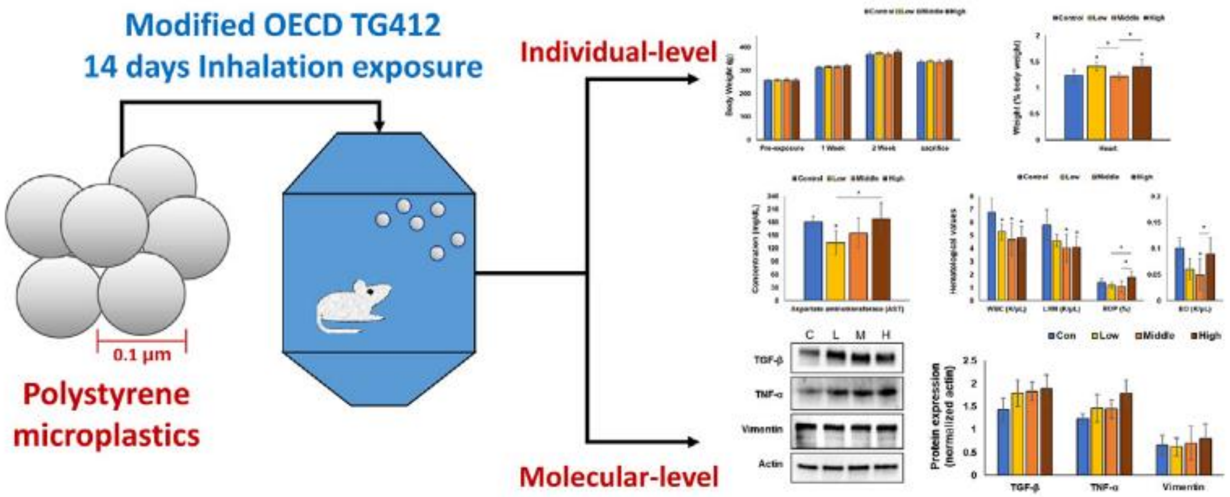
[b] Bio Technology Division, Korea Conformity Laboratories, 8, Gaetbeol-ro 145beon-gil, Yeonsu-gu, Incheon, 21999, Republic of Korea
[c] Department of Nanofusion Technology, Hoseo University, 20, Hoseo-ro 79beon-gil, Baebang-eup, Asan, 31499, Republic of Korea

- Six-week-old male and female Sprague-Dawley rats
- Exposed to 3 different concentrations of polystyrene micro(nano)plastics (PSMPs), as well as control
- After 14 days, alterations were observed on sevral endpoints in physiological, serum biochemical, hematological, and respiratory function markers



Chemosphere. 2021 Jan;262:128330.

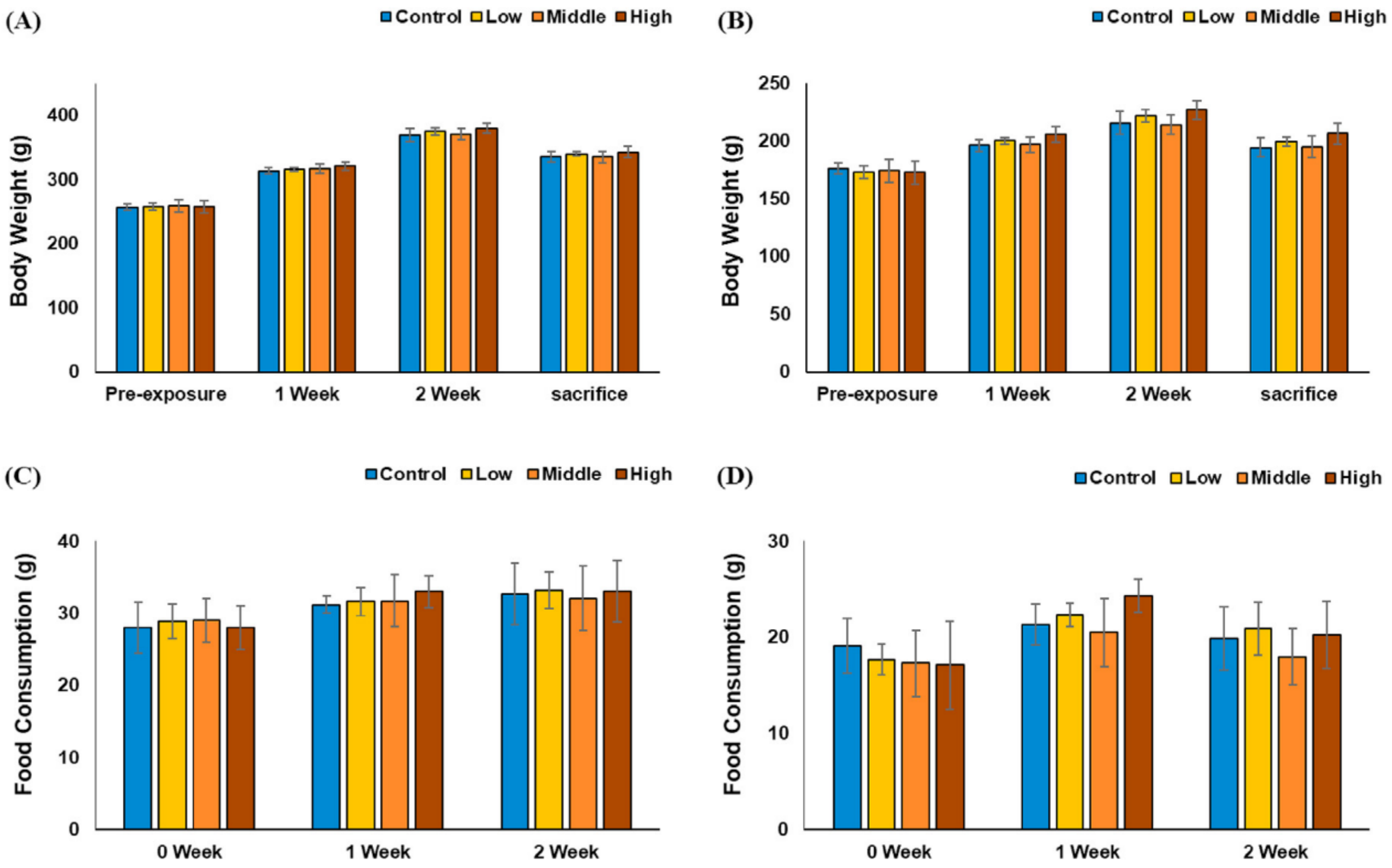


Fig. 3. Effect of micro(nano)plastics on body-weight (**A**: male, **B**: Female) and food consumption (**C**: male, **D**: Female). Body-weight and food consumption were measured on the rats exposed to micro(nano)plastics for 14 days.

Chemosphere. 2021 Jan;262:128330.

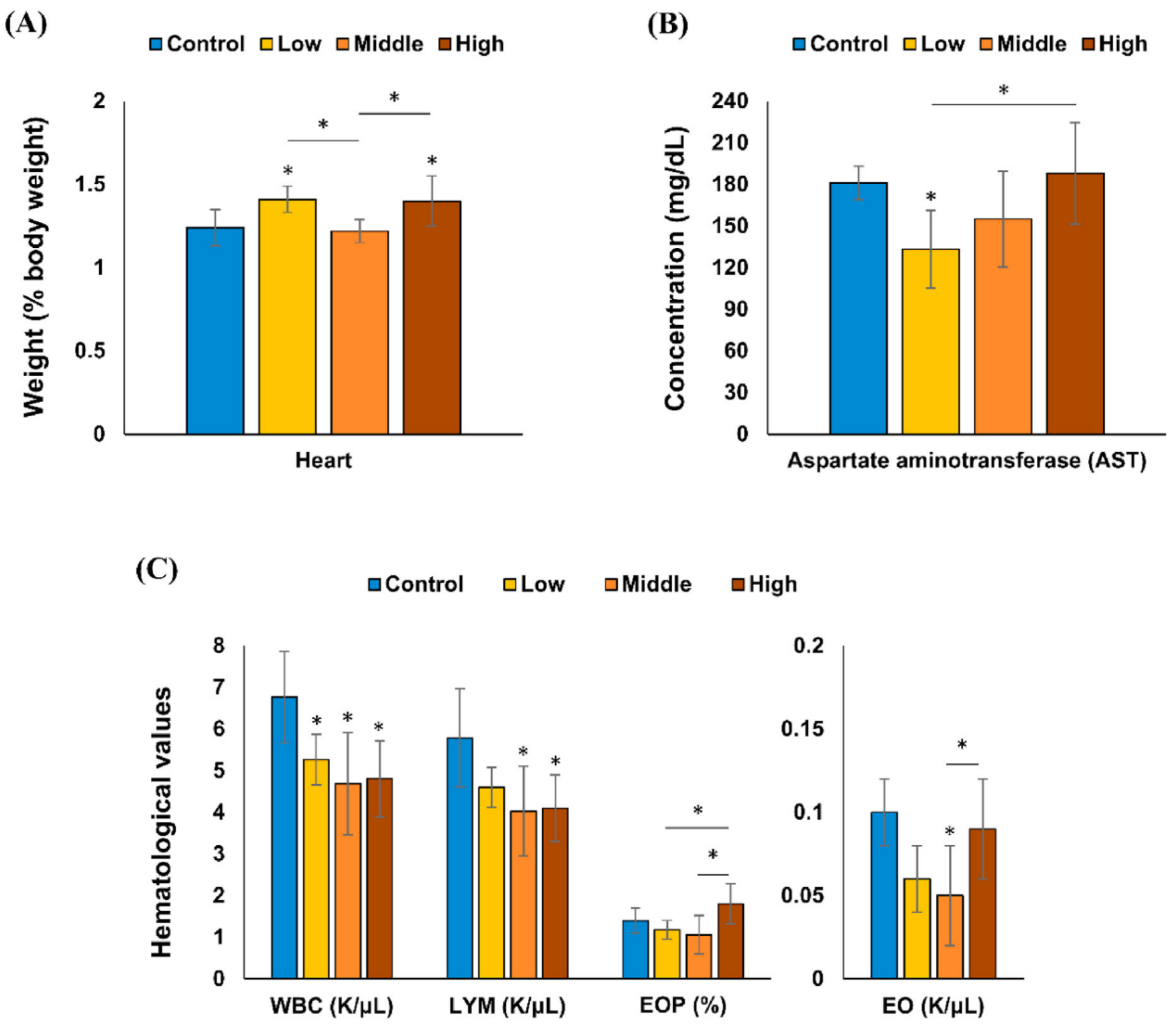


Fig. 4. Effect of micro(nano)plastics on organ weight of male rats (**A**), serum biochemical values of male rats (**B**) and hematological values of female rats (**C**). Results were measured on the rats exposed to micro(nano)plastics for 14 days. WBC, white blood cell; LYM, lymphocyte; EOP, percent of eosinophil; EO, eosinophil. *$p < 0.05$.

Chemosphere. 2021 Jan;262:128330.

Table 3
Effect of micro(nano)plastics on the pulmonary function of rats after inhalation exposure to micro(nano)plastics for 14 days (n = 5 for each group).

GROUP (mean ± S.D)	Male				Female			
	Control	Low	Middle	High	Control	Low	Middle	High
f[a]	117.48 ± 6.58	115.06 ± 4.99	117.52 ± 5.58	116.01 ± 7.13	95.88 ± 3.83	103.51 ± 11.71	94.33 ± 3.76	**102.56 ± 8.39***
TV[b]	1.42 ± 0.26	1.44 ± 0.23	1.37 ± 0.22	1.39 ± 0.32	1.39 ± 0.32	1.40 ± 0.37	1.18 ± 0.13	1.33 ± 0.35
MV[c]	166.46 ± 32.27	164.51 ± 22.66	183.63 ± 55.97	162.03 ± 38.59	133.96 ± 34.04	147.45 ± 50.76	111.73 ± 14.50	137.22 ± 42.11
Ti[d]	0.24 ± 0.02	**0.18 ± 0.05***	**0.16 ± 0.04***	**0.16 ± 0.03***	0.24 ± 0.01	**0.16 ± 0.04***	0.21 ± 0.05	0.21 ± 0.03
Te[e]	0.27 ± 0.02	0.29 ± 0.06	0.27 ± 0.07	0.27 ± 0.05	0.43 ± 0.01	**0.30 ± 0.08***	0.38 ± 0.06	**0.33 ± 0.02***
PIF[f]	12.74 ± 8.10	18.36 ± 6.22	21.46 ± 14.83	18.91 ± 10.35	13.71 ± 9.24	16.51 ± 5.29	14.35 ± 6.32	13.70 ± 6.38
PEF[g]	11.29 ± 4.62	13.30 ± 6.63	14.75 ± 9.37	13.36 ± 9.38	8.52 ± 4.08	9.30 ± 3.36	9.52 ± 4.42	8.67 ± 4.07

*: P < 0.05 vs. control group.
[a] Frequency(BPM).
[b] Tidal Volume(ml).
[c] Minute Volume(ml/min).
[d] Inspiratory Time(sec).
[e] Expiratory Time(sec).
[f] Peak Inspiratory Flow(ml/sec).
[g] Peak Expiratory Flow(ml/sec).

Chemosphere. 2021 Jan;262:128330.

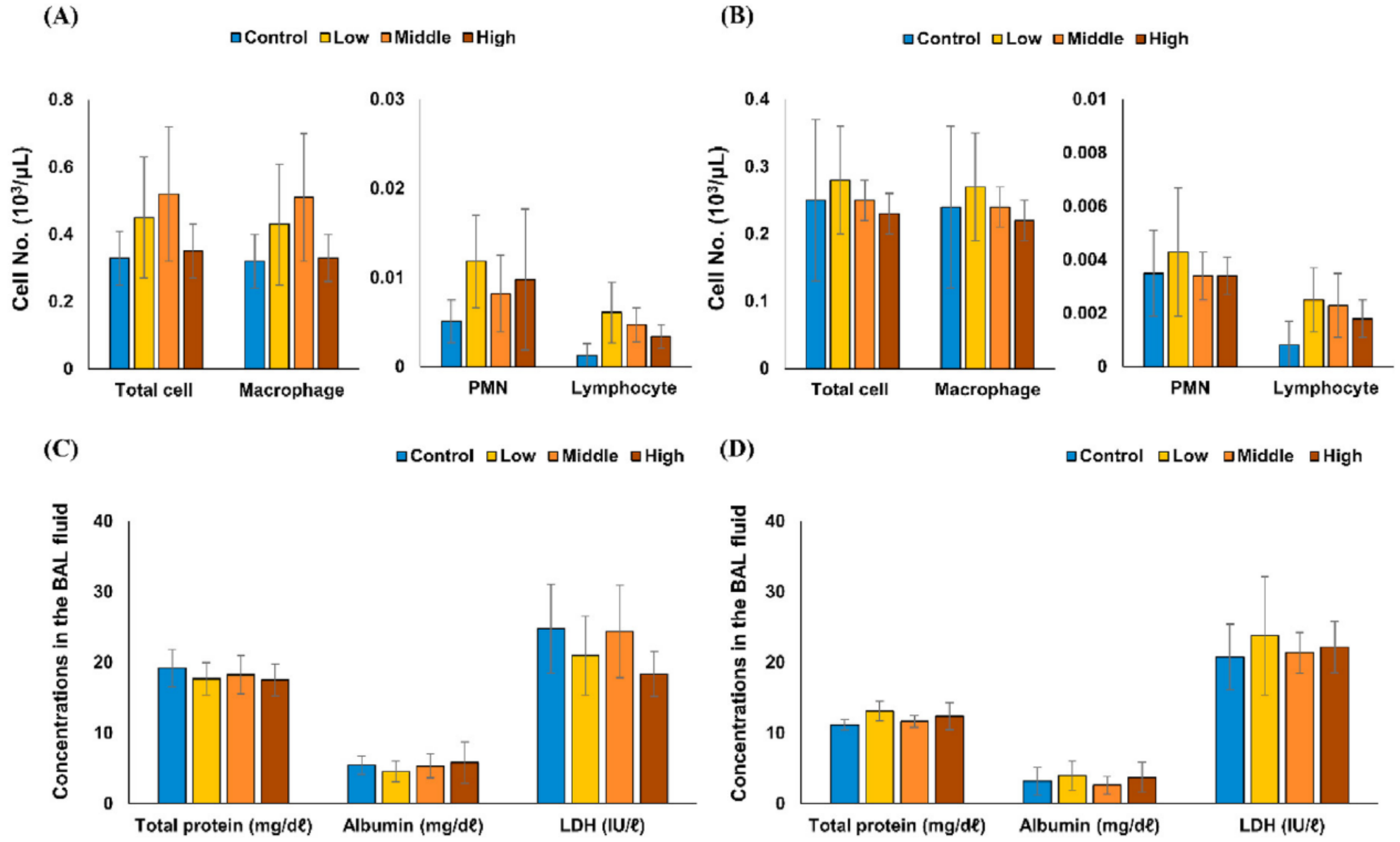


Fig. 5. Effect of micro(nano)plastics on cell number in broncholaveolar lavage (BAL) fluid (**A**: male, **B**: female) and inflammatory markers in BAL fluid (**C**: male, **D**: female). BAL cell number and levels of inflammatory markers were measured after 14 days of inhalation exposure of micro(nano)plastics.

Chemosphere. 2021 Jan;262:128330.

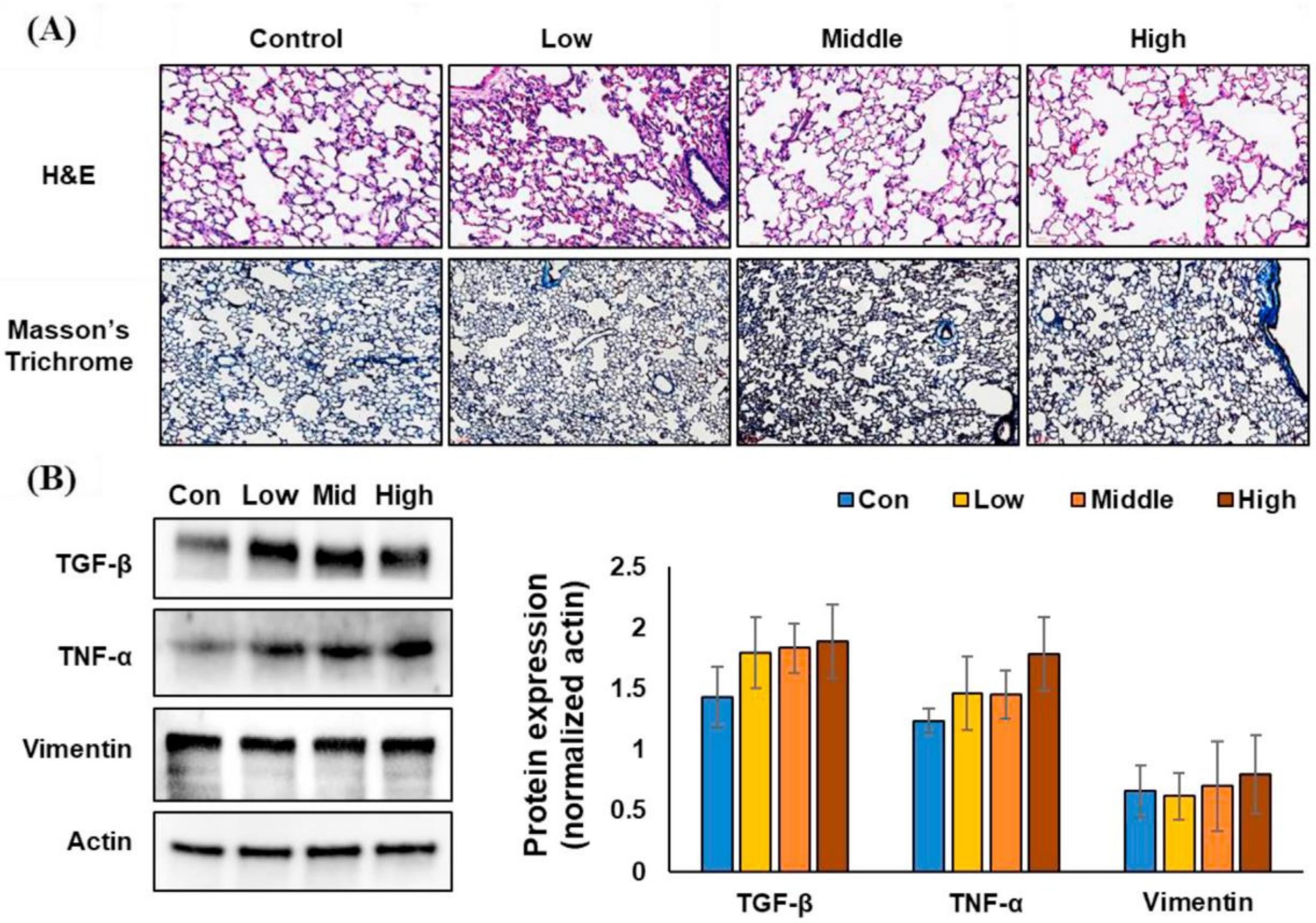


Fig. 6. Histopathology of lung (right) tissue (**A**), and protein expression of TGF-β, TNF-α, and vimentin (**B**). Histological analysis of lung tissue was performed using Hematoxylin-Eosin and Masson's trichrome staining. Lysates of lung tissue (control, low-, middle- and high-concentration) were used for western blotting with indicated antibodies (TGF-β, TNF-α, and vimentin). The Western blot band intensities were measured with Image Lab™. TGF-β, TNF-α, and vimentin protein levels were normalized to β-actin levels.

Chemosphere. 2021 Jan;262:128330.

Table 4
Summary of inhalation toxicity of polystyrene micro(nano)plastics (PSMPs).

Markers	Parameters	Results
General physiology	Body weight	No change
	Food consumption	No change
	Organ weight	Heart weight was increased in male rats
	Serum biochemistry	AST level was decreased in male rats
	Hematology	WBC, LYM, EO level were decreased in female rats
Pulmonary pathology	Lung function	Inspiratory time was decreased in male rats
		Respiratory frequency was increased, and inspiratory time and expiratory time were decreased in female rats
	BAL cell count	No change
	Collagen	No change
	Inflammation	Increase

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Journal of Hazardous Materials 416 (2021) 126069

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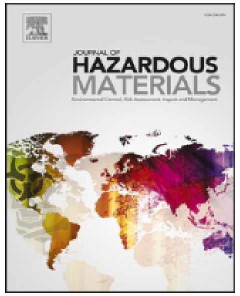

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Research Paper

Detrimental effects of microplastic exposure on normal and asthmatic pulmonary physiology

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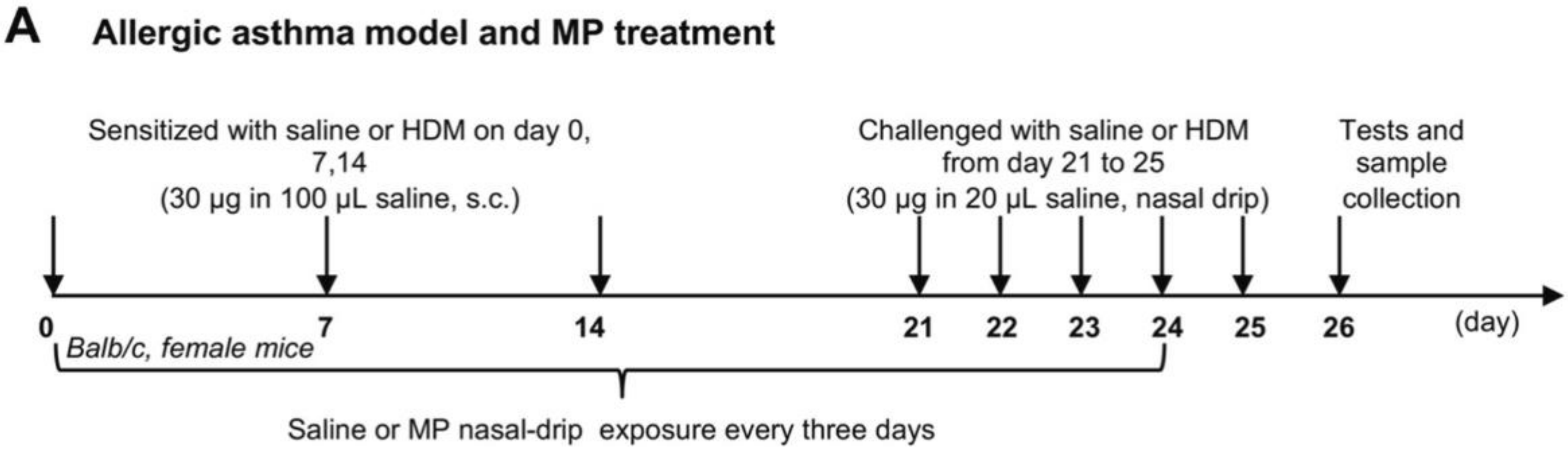

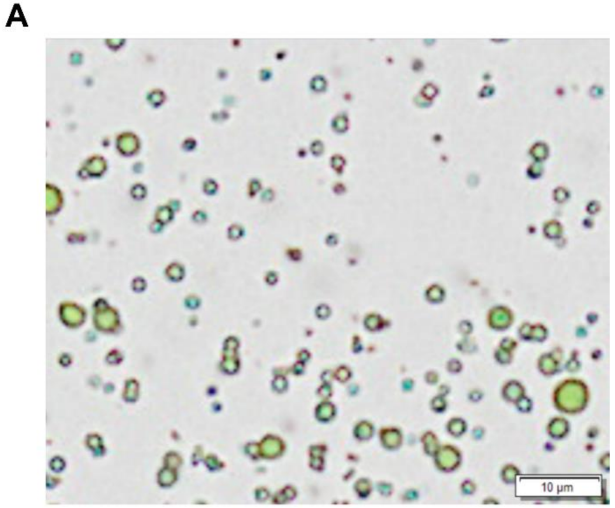

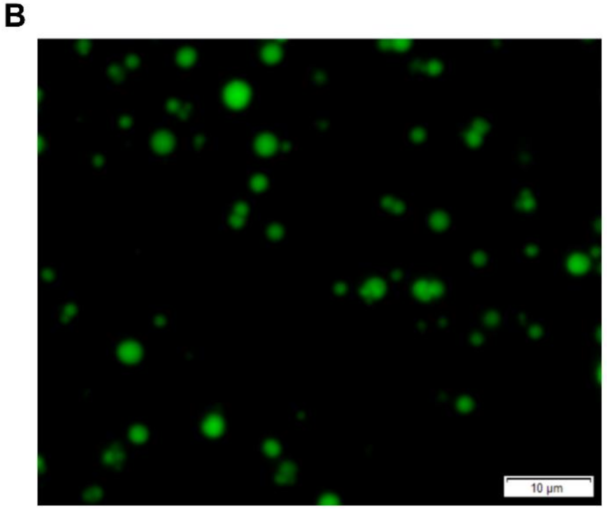

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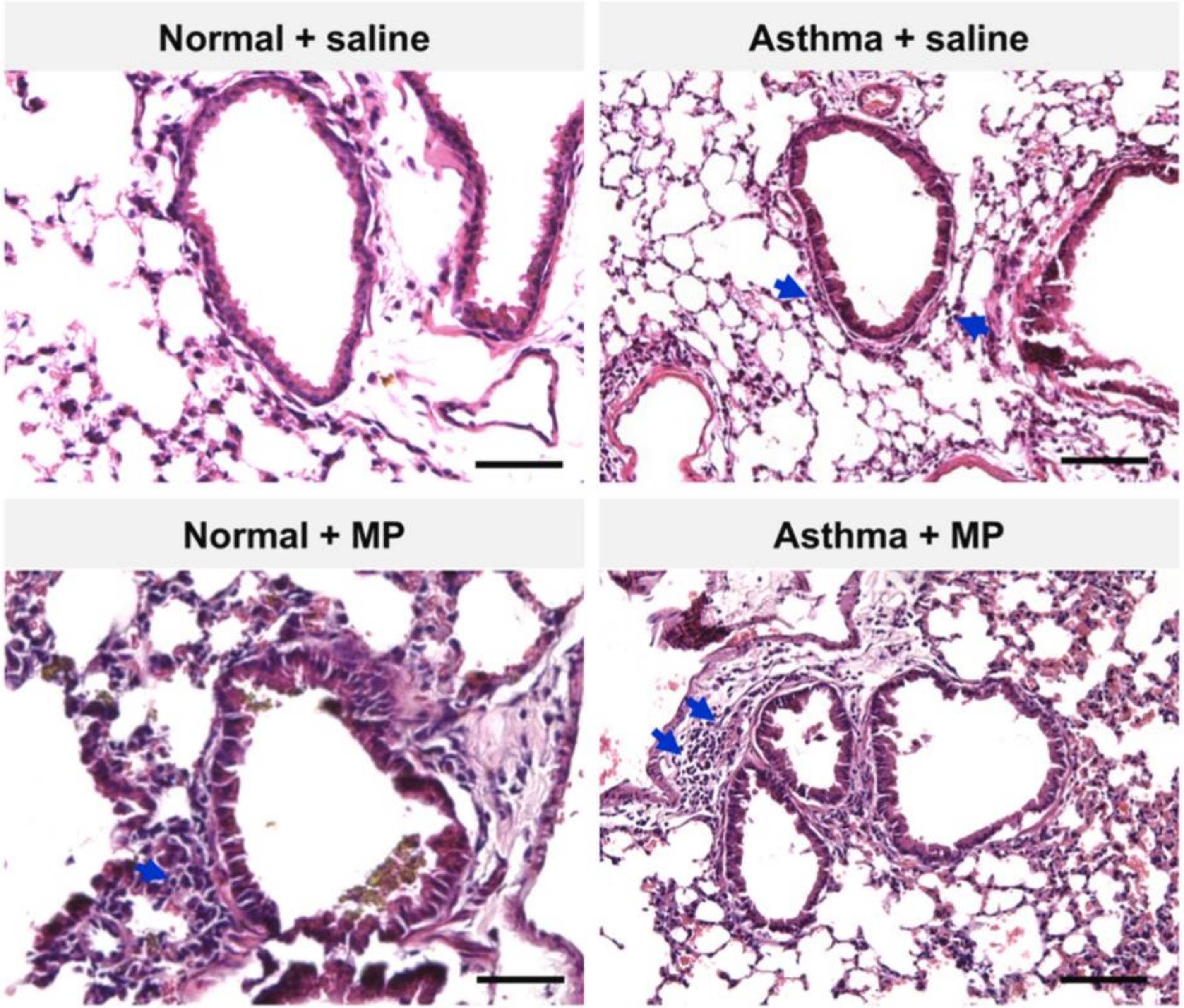

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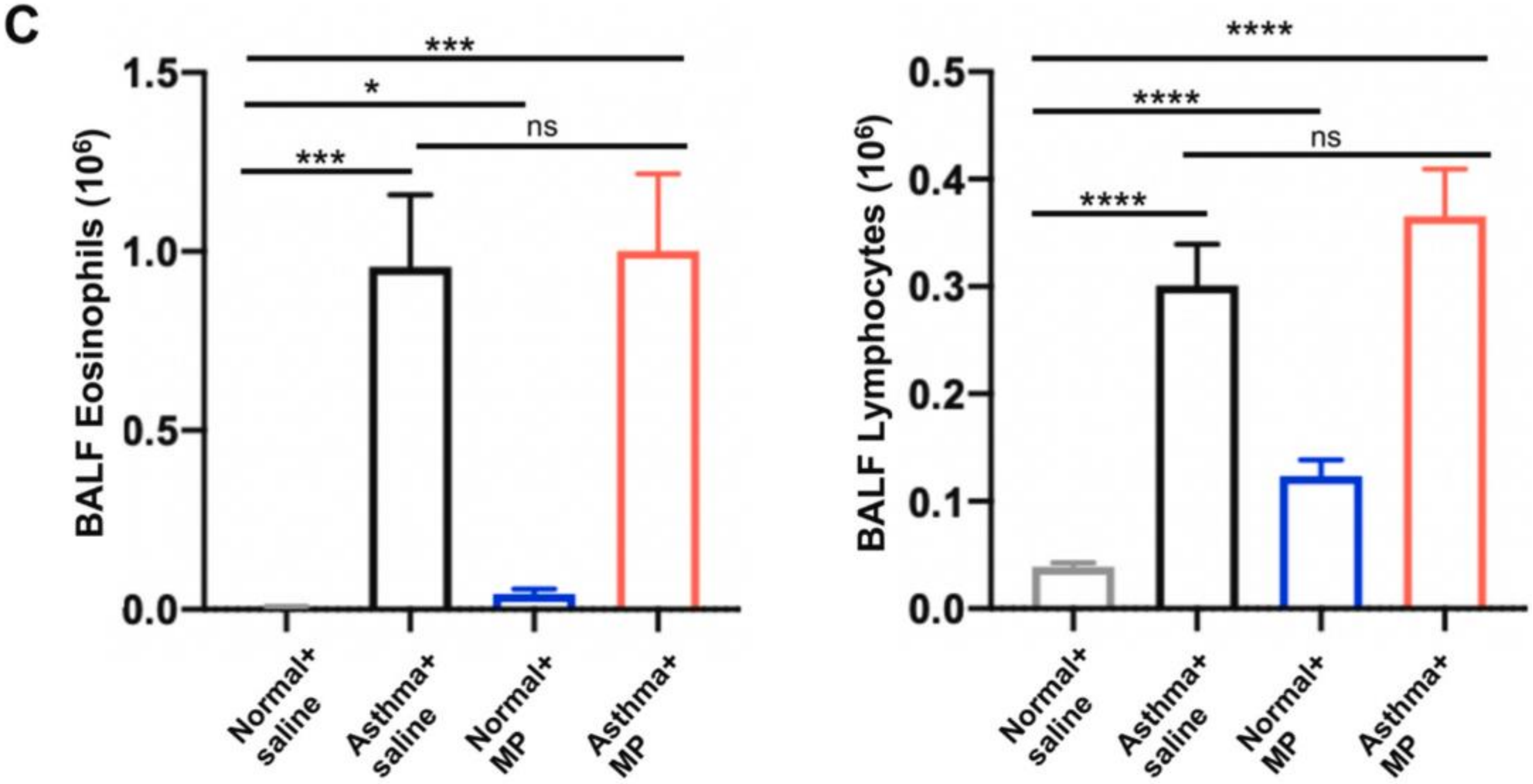

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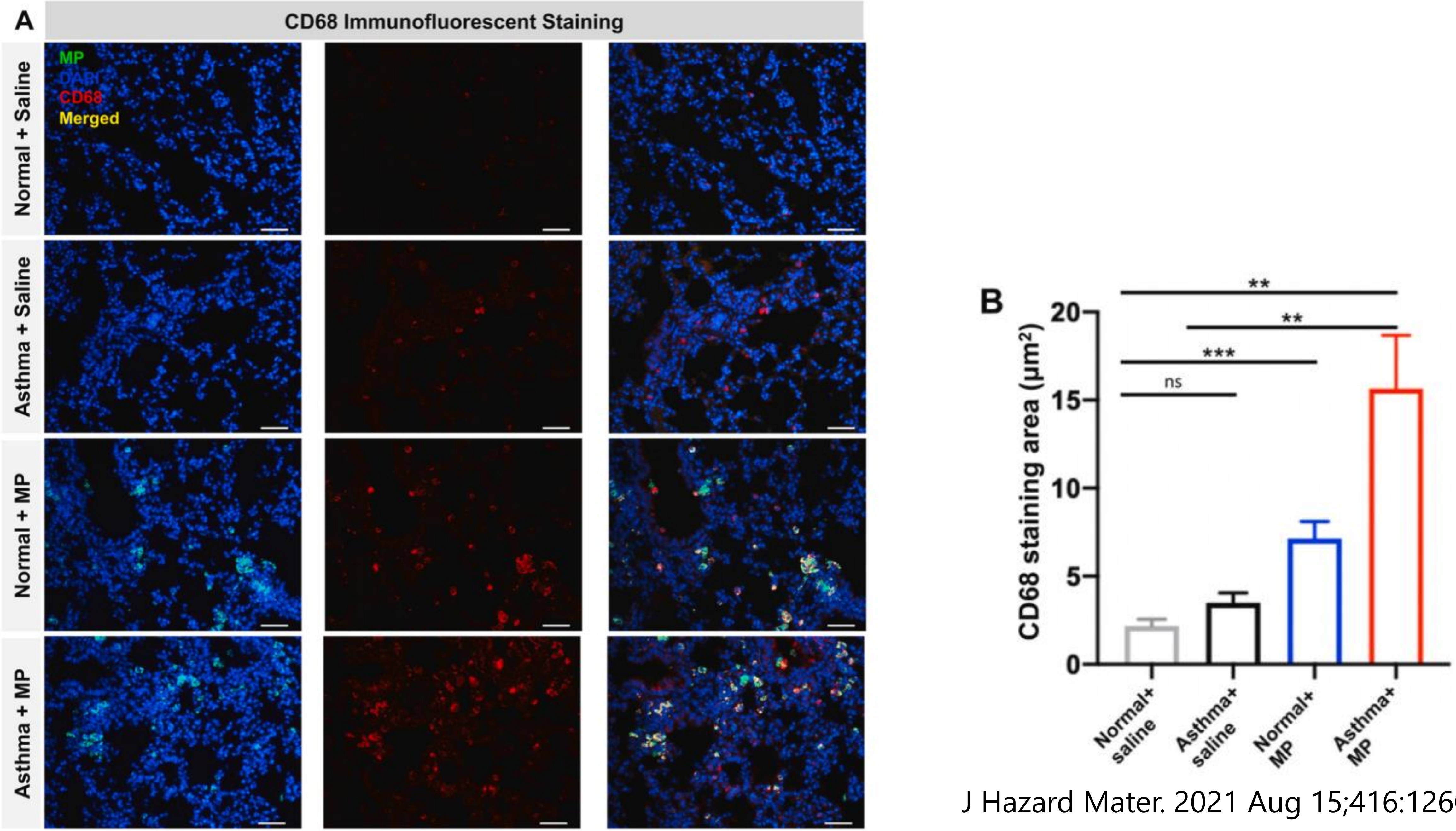

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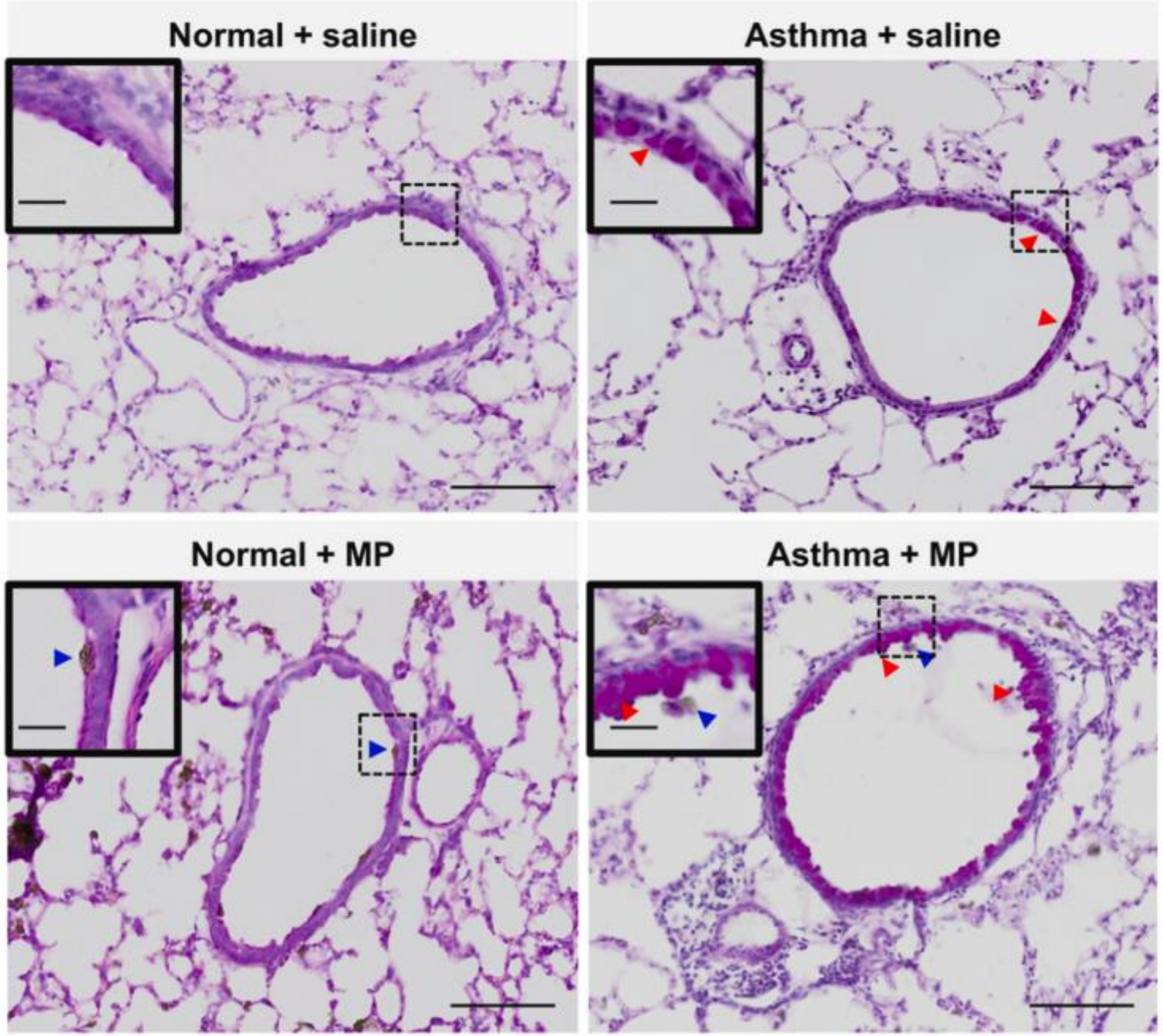

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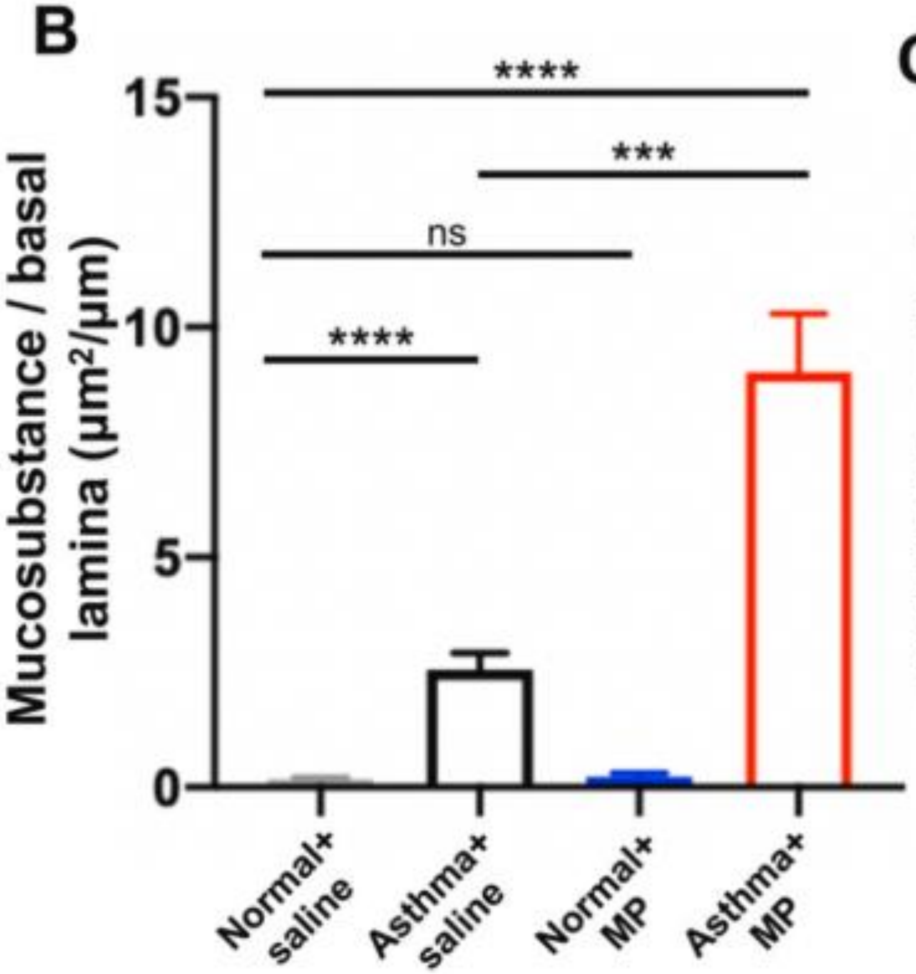

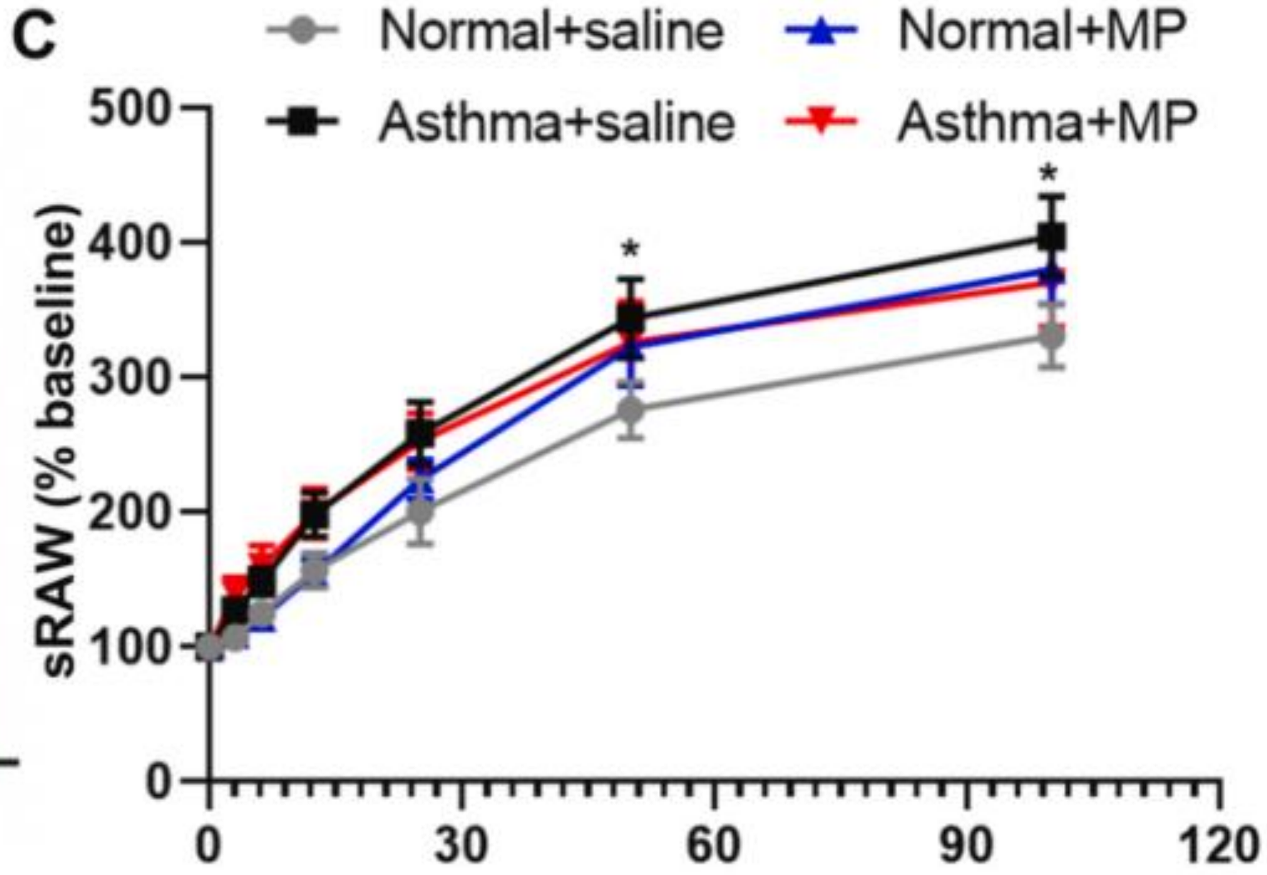

(*normal + saline vs Asthma + MP, analyzed with two-way ANOVA).

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- MP exposure caused
  - pulmonary inflammatory cell infiltration,
  - broncho-alveolar macrophage aggregation,
  - increased TNF-α level in bronchoalveolar lavage fluid (BALF)

- MP exposure also affected asthma symptoms
  - increasing mucus production
  - inflammatory cell infiltration
  - notable macrophage aggregation.

In summary,

- Microplastic everywhere
- Maybe an important PM (particle matter)
- Clue from old epidemiologic studies
  - MP may induce lung fibrosis, granuloma, lung cancer
- Found in human blood, sputum, urine, lung tissue
- In vitro studies
  - MP induces cell death, inflammation, oxidative stress and decrease epithelial integrity
  - Maybe associated with COPD
- In vivo studies
  - Associated with lung inflammation and macrophage aggregation
- Future studies are needed to conclude hazardous effect of MP in human health.