

**Occurrence and distribution of microplastic and mesoplastic in the nature reserve,
northern China**

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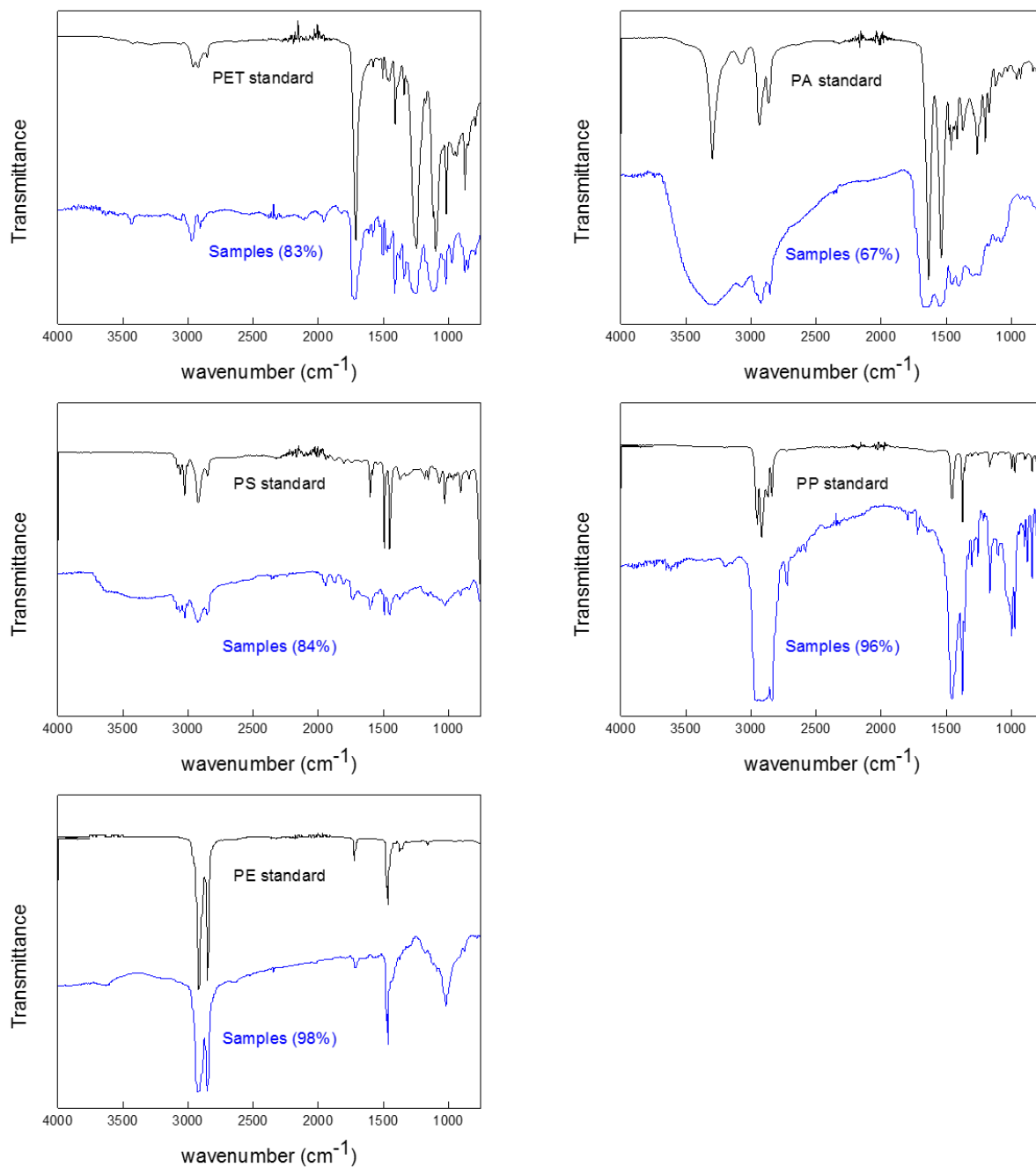


Fig. S1 Typical infrared spectra of the randomly selected micro(meso)plastics from surface water and sediment from the Liaohe River Reserve

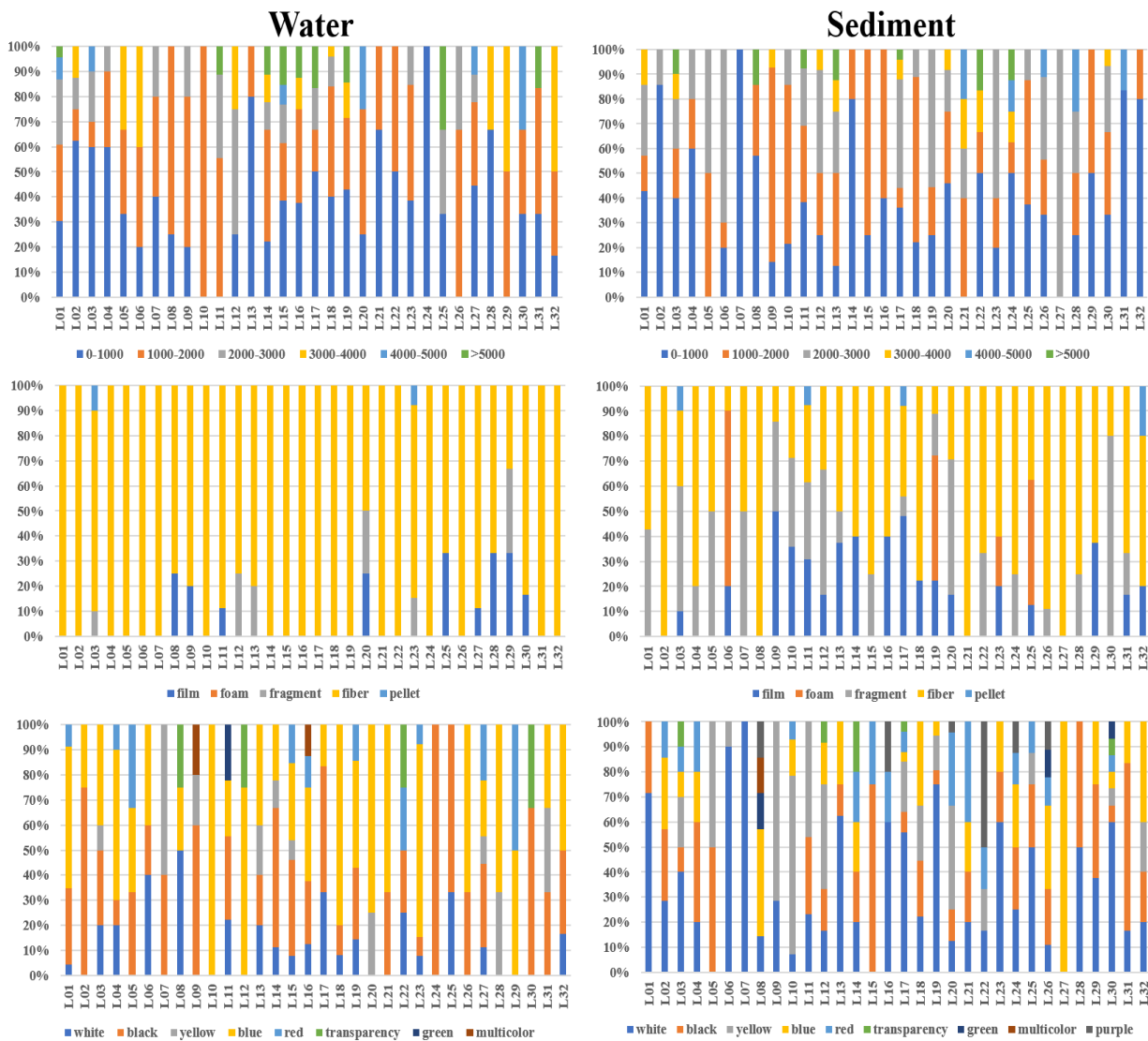


Fig. S2 Percentage of micro(meso)plastics in surface water and sediment at each site, according to size (a), shape (b) and color (c).

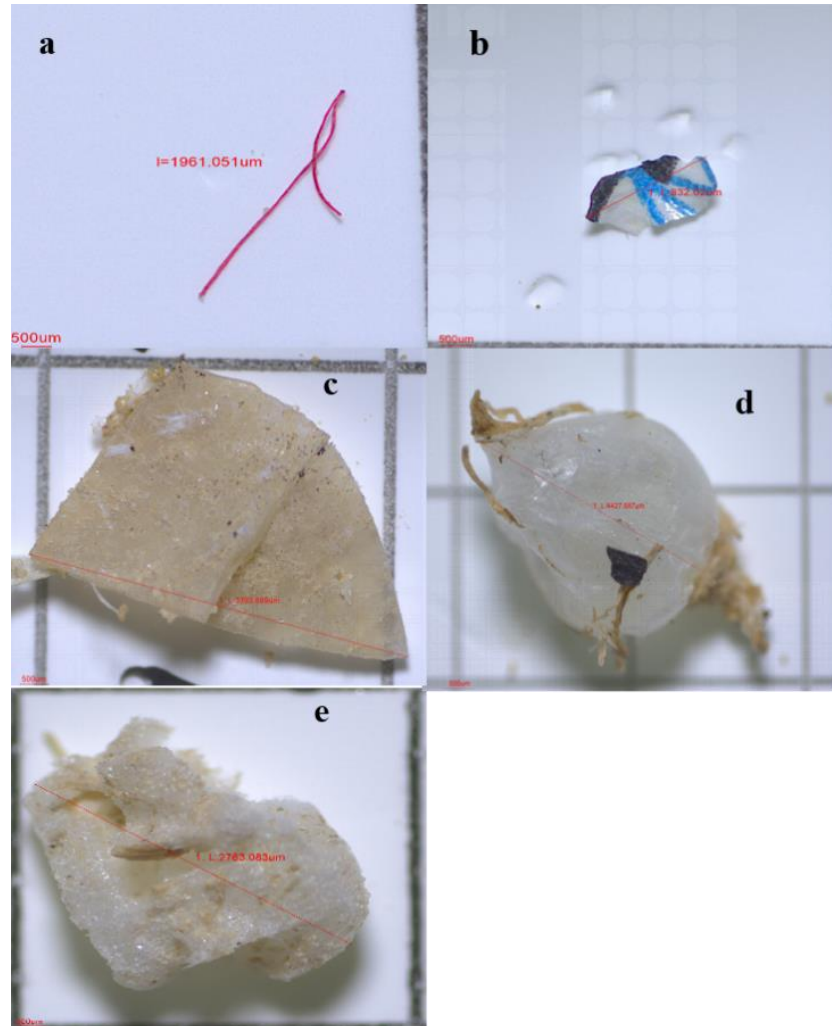


Fig. S3 Microscopic examination of micro(meso)plastics in surface water and sediment from the Liaohe River Reserve (magnification, $\times 20$; a fiber, b film, c fragment, d pellet and e foam)

Table S1. Data details of the flow rate, turbidity, county populations of each site and spacial distance from the sampling site to the city center.

Sampling site	Flow rate (m/s)	Turbidity (NTU)	County populations ($\times 10^4$)	Spacial distance (km)
L1	0.1	56.37	99.26	86.86
L2	0.5	74.50	34.23	116.71
L3	0.1	9.43	34.23	101.86
L4	0.6	95.37	34.23	101.11
L5	0.1	130.67	99.26	47.24
L6	0.2	96.70	43.83	93.55
L7	0.5	100.63	56.08	37.56
L8	0.5	111.00	56.08	26.72
L9	0.1	18.17	56.08	27.52
L10	0.3	49.77	56.08	25.09
L11	0.1	3.89	31.33	16.15
L12	0.7	88.17	31.33	16.42
L13	0.2	36.27	37.86	10.45
L14	0.3	8.05	43.83	53.24
L15	0.4	100.10	37.86	13.39
L16	0.1	114.33	37.86	19.57
L17	0.1	67.57	32.90	38.97
L18	0.6	75.67	66.61	45.25
L19	0.2	112.67	66.61	46.60
L20	0.5	301.00	66.61	47.67
L21	0.5	64.10	66.61	54.23
L22	0.3	71.90	66.61	47.06
L23	0.3	26.50	66.61	59.41
L24	0.4	92.90	66.61	46.89
L25	0.4	129.33	51.44	59.75
L26	0.2	125.33	51.44	72.35
L27	0.5	142.00	36.51	44.10
L28	0.3	42.43	36.51	56.77
L29	0.1	33.53	43.92	7.84
L30	0.3	220.00	27.38	21.34
L31	0.1	159.33	39.13	17.65
L32	0.2	44.10	19.50	10.96

Table S2. Average composition of polymer types determined by ATR-FTIR analysis in the surface water and sediment samples from the Liaohe River Reserve.

Polymer types	Abbreviation	Proportion in (%)	
		Surface water	Sediment
Polyethylene	PE	0.90	2.34
Polypropylene	PP	1.81	3.34
Poly(ethylene terephthalate)	PET	7.69	4.01
Polyester	PES	19.46	5.02
Poly(octadecyl acrylate)	POA	1.36	2.01
Rayon	RY	56.11	32.44
Styrene-Butadiene-Styrene	SBS	4.07	7.02
Poly(N-methyl acrylamide)	PNMAA	0.45	2.68
urea-formaldehyde resin	UF	0.90	1.00
Poly(ethylene:4-methyl-1-pentene)	PE/PMP	0.90	0.33
Cellphane	-	1.36	6.69
Poly(acrylonitrile:acrylic acid)	PAN/PAA	2.71	3.68
Chlorinated polyolefin	CPO	0.90	0.33
Polyether urethane, poly(butylene oxide) + methylene bis(phenylisocyan)	-	0.45	ND
Poly(dicycloundecyl itaconate)	-	0.45	ND
Grilon CR 9	PA612	0.45	ND
Polyamide	PA	ND	6.69
Polystyrene	PS	ND	17.06
Polyallyl acetate	PAAC	ND	1.00
Polymethyl methacrylate	PMMA	ND	0.33
Polyacrylamide	PAM	ND	0.67
Polyvinylalcohol	PVA	ND	0.33
Poly(1-dodecene), isotactic	-	ND	0.33
Poly(1-tetradecene), isotactic	-	ND	0.33
Poly(vinylidene fluoride: hexafluoropropene)	-	ND	1.00
Poly(nitro-1,4-phenylene-4,4'-azobisbenzamide)	-	ND	0.33
Poly(diacetylene diester)	-	ND	0.33
Poly(1,4-phenylene-3,3'-dioxo-5,5'-biindol-2,2'-diyl)	-	ND	0.33
Poly(oxothioxoquinazoline terephthalimide)	-	ND	0.33
		ND	

Table S3. Micro(meso)plastic polymer types of different shapes in surface water.

Polymer types	Surface water (items L ⁻¹)			
	Film	Fragment	Fiber	Pellet
CPO	0.05	0.05	0.00	0.00
PE	0.05	0.00	0.05	0.00
PA612	0.00	0.00	0.05	0.00
PAN/PAA	0.00	0.00	0.30	0.00
PE/PMP	0.10	0.00	0.00	0.00
PES	0.00	0.05	2.10	0.00
PET	0.00	0.05	0.80	0.00
PNMAA	0.00	0.00	0.00	0.05
POA	0.15	0.00	0.00	0.00
Poly(dicycloundecyl itaconate)	0.05	0.00	0.00	0.00
Polyether urethane, poly(butylene oxide) + methylene bis(phenylisocyan	0.00	0.00	0.05	0.00
PP	0.05	0.05	0.10	0.00
PT	0.00	0.00	0.15	0.00
RY	0.05	0.10	6.00	0.05
SBS	0.00	0.00	0.45	0.00
UF	0.00	0.00	0.10	0.00
Total	0.50	0.30	10.15	0.10

Table S4. Micro(meso)plastic polymer types of different shapes in sediment.

Polymer types	Sediment (items kg ⁻¹)				
	Film	Pellet	Foam	Fragment	Fiber
PE	100	0	0	40	0
PP	20	20	0	120	40
PS	80	0	600	320	20
RY	400	0	0	420	1120
PES	0	0	0	20	280
PT	0	0	0	80	320
PAAC	0	0	0	60	0
PET	0	0	0	20	220
PMMA	0	0	0	20	0
PVA	0	0	0	0	20
PAN/PAA	0	0	0	0	160
CPO	20	0	0	0	0
PA	160	0	0	220	20
PAA,DFA	60	0	0	0	0
PAM	40	0	0	0	0
PE/PMP	20	0	0	0	0
PNMAA	100	0	0	20	40
POA	100	0	0	20	0
SBS	80	0	0	40	300
UF	20	0	0	40	0
Poly(1-tetradecene), isotactic	20	0	0	0	0
Poly(1,4-phenylene-3,3'-dioxo-5,5'-biindol-2,2'-diyl)	0	20	0	0	0
Poly(1-dodecene), isotactic	0	20	0	0	0
Poly(nitro-1,4-phenylene-4,4'-azobisbenzamide)	0	20	0	0	0
Poly(oxothioquinazoline terephthalimide), C24	0	20	0	0	0
Poly(vinylidene fluoride:hexafluoropropene)	0	0	0	0	60
Poly(diacetylene diester)	0	0	0	20	0
Total	1220	100	600	1460	2600

Risk assessment

The assessment of microplastic risk needs to take into consideration factors that are relevant to both the abundance and the chemical composition of microplastics. Thus, two indicators, *i.e.*, the risk index (H) and the pollution load index (PLI), were combined to evaluate the potential risks of microplastics in surface water and sediment from the Liaohe River Reserve. The risk index (H) values based on the chemical composition of microplastics were used to preliminarily assess the risks of microplastics according to the method developed by Lithner et al (2011) and Xu et al (2018). The formula with hazard scores for different polymer types as the indicators is as follows,

$$H = \sum S_n \times P_n \quad (\text{Eq. 1})$$

where S_n is the polymer hazard score and P_n is the percentage of polymer for each component at each site. The S_n is listed in the supporting information Table S4. It should be noted that a high proportion of rayon has been found both in surface water and sediment in the Liaohe Reserve. However, due to the lack of ecological toxicity data, the hazard score of rayon cannot be determined. Therefore, rayon was not included in the calculation of the risk index in this study.

The pollution load index (PLI) associated with the microplastic abundance in each site was used to evaluate the level of microplastic pollution:

$$CF_i = C_i/C_{oi} \quad (\text{Eq. 2})$$

$$PLI = \sqrt{CF_i} \quad (\text{Eq. 3})$$

$$PLI_{zone} = \sqrt[n]{PLI_1 \times PLI_2 \times \dots \times PLI_n} \quad (\text{Eq. 3})$$

The CF_i is the quotient of the microplastic abundance at each station (C_i) and the minimal microplastic

abundance (C_{oi}). The C_{oi} value was selected as 5×10^{-4} items L^{-1} for surface water (Xu et al., 2018) and 2 items kg^{-1} for sediment (Dekiff et al., 2014). The PLI in the Liaohe River Reserve (PLI_{zone}) was obtained by the n th root of the total PLI at each site multiplied together. At present, there is no uniform standard for the risk level criteria. The criteria for microplastic pollution proposed by Xu et al. (2018) was employed herein (Table S5).

Table S5. Detailed information for microplastic polymers detected in this study, including monomer, density and score.

Polymer	Abbreviation	Monomer	Density ($g\ cm^{-3}$)	Score ^a
Polyethylene	PE	ethylene	0.89–0.98	11
Polypropylene	PP	polypropylene	0.85–0.92	1
Polyethylene terephthalate	PET	ethylene glycol	1.38–1.41	4
Urea-formaldehyde resin	UF	formaldehyde	1.17	1500
Polyamide (nylon)	PA	adipic acid	1.14–1.15	47
Polystyrene	PS	styrene	1.014–1.1	30
Polyacrylonitrile	PAN	acrylonitrile	1.184	11521
Polyacrylic acid	PAA	acrylic acid	1.09	230
Polycarbonate	PC	bisphenol A	1.19	1177

^a the value for the score of each polymer which is taken from Lithner et al. (2011).

Table S6. Risk index and risk level of micro(meso)plastic in the Liaohe River Reserve.

		Risk Index (H)			
		Risk category			
	Average	I (<10)	II (10–100)	III (100–1000)	IV (> 1000)
Surface water	14.9	All sites except L6 and L7		L6, L7	
Sediment	8.9	L1-L4, L12, L13, L15, L16, L21, L22, L24, L26, L27, L28, L30, L31	L7, L9, L10, L14, L19, L20, L25, L32	L5, L6, L11, L17, L29	L8, L18, L23,
		Pollution load index (PLI)			
		Risk category			
	Average	I (<10)	II (10–20)	III (20–30)	IV (>30)
Surface water	13.4	L5, L10, L21, L24-L26, L28, L31, L32	L2-L4, L6-L9, L11-L14, L16, L17, L19, L20, L22, L27, L29, L30	L1, L15, L18, L23,	
Sediment	4.9	All sites except L19		L19	

Reference

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- Xu, P., Peng, G., Su, L., Gao, Y., Gao, L., Li, D. 2018. Microplastic risk assessment in surface waters: a case study in the Changjiang Estuary, China. *Mar. Pollut. Bull.*, 133, 647-654.
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