

# Field Survey of Indoor Microplastic in Four Regions of Japan

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**Abstract.** In recent years, the plastics pollution of 5mm or less size (microplastics) in marine ecosystems has been a global issue. The presence of microplastics (microfibers) is also a major concern in indoor environments of the residential house. Many sources of microplastics in the marine environment also exist in the indoor environment. In the modern age where we spend most of our time indoors, the indoor environment is related to the health of residents, so it is important to investigate the presence and contamination status of microplastics in the indoor environment. There is limited the number of studies on microplastics in the indoor environment. In our previous studies have confirmed the presence of microplastics in indoor environments Kanto area including Tokyo of Japanese residential houses. The purpose of this study is to investigate the concentration of indoor microplastics in four regions; Kanto area including Tokyo, Chubu area, Tohoku area, and Kansai area. We focused on the indoor microplastics in settled dust on the floor of residential houses, and the survey was conducted on the 16 residential houses. Micro-Fourier transform infrared ( $\mu$ -FT-IR) spectrophotometry was used for the qualitative analysis of microplastics. The detected components in the settled dust were cellulose, polyamide (PA), polyacrylamide (PAM), polyacrylonitrile (PAN), polybutylene terephthalate (PBT), polyethylene (PEs), polyester (PE), polyethylene terephthalate (PET), polypropylene (PP), polyvinyl acetate (PVAL).

## 1 Introduction

The plastics pollution of 5mm or less size (microplastics) in marine ecosystems has been a global issue in recent years<sup>1-3</sup>). The most commonly manufactured plastics in marine ecosystems were polypropylene, polyethylene, polyethylene terephthalate, polystyrene and polyurethane. Many of the microplastics detected in the marine environment also exist in the indoor environment, and many of them were extracted from the indoor environment. The survey on presence and concentration of microplastics in indoor environments is required from the point of view on maintaining indoor air quality for the health of residents. Recently, the survey concerning the microplastics pollution in indoor air is conducted and reported (2015, Dris et al.)<sup>4</sup>). Compared to the field survey data on microplastics in the ocean, that on microplastics in indoor environments still limited. In particular, little research has been conducted on microplastics in the indoor environment in Japan<sup>5-6</sup>).

The purpose of this study was to investigate the presence of microplastics in the indoor environment of Japan. The survey was conducted totaly 16 residential

houses in four regions; Tohoku, Chubu, Kato, and Kansai regions.

## 2 Methods

### 2.1 Target houses

Fig.1 shows the locations of residential houses surveyed in this survey<sup>5</sup>), and Table1 shows the detail information of the house. The number of residents were one to four persons. The structure of the target houses included nine wooden buildings, three reinforced concrete buildings, and five steel buildings. Both apartment and standalone house were considered. The floor materials of the houses wooden flooring tile and wooden flooring.

### 2.2 Protocol of survey

Owing to the limited number of studies on indoor microplastic concentrations, there is no standardized sampling or measurement method for indoor microplastics to ensure reproducibility; therefore, it is necessary to first establish sampling, measurement, and analysis protocols, especially considering the characteristics of indoor environmental conditions. The

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points to be addressed includes the definitions of indoor microplastics, qualitative and quantitative measurement methods, and universal assessment procedures. To quantitatively address the presence or potential presence of microplastics in the indoor environment, previously reported methods of sampling house dust, classification, and compositional analysis were studied<sup>5)</sup>. Based on a thorough literature review, a protocol for the sampling and analysis of indoor microplastics was developed, as shown in the Fig. 2<sup>6)</sup>. In this survey, we analyzed the components of microplastics in house dust that settled on the floor, which was collected using a household vacuum cleaner. After removing hair from the collected house dust, it was classified in seven sizes, and the shape of samples were observed. The samples were then subjected to qualitative analysis using micro Fourier Transform Infrared Spectroscopy ( $\mu$ -FT-IR).

### 2.3 Classification and Observation

After pre-treatment of the house dust collected for  $\mu$ -FT-IR analysis, it was further classified in seven sizes using a fully automatic shaker and the sieves of seven mesh levels; > 5600  $\mu$ m, 5600- 2000  $\mu$ m, 2000- 500  $\mu$ m, 500- 250  $\mu$ m, 250- 100  $\mu$ m, 100- 45 $\mu$ m, and < 45  $\mu$ m. After the dust sample was classified, its shape was observed using an optical microscope for each classification size. In addition, scanning electron microscopy (SEM) was used to observe minute surface structures that could not be observed using an optical microscope.

### 2.4 Qualitative analyses

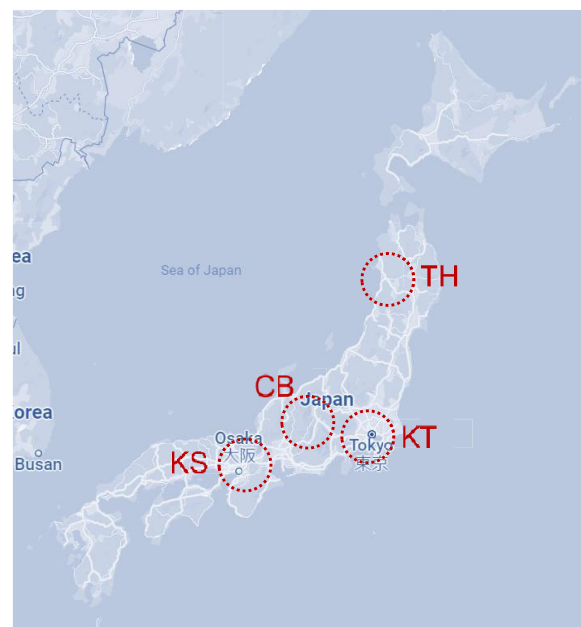
The samples for qualitative analysis were prepared by potassium bromide (KBr) plates method. The KBr plate method is advantageous for eliminating the influence of ambient humidity, suppressing baseline bending due to scattering, and preventing the generation of interference fringes on smooth, thin samples. The samples were then subjected to qualitative analysis using micro Fourier Transform Infrared Spectroscopy ( $\mu$ -FT-IR). The  $\mu$ -FT-IR analysis yielded the molecular structure of the organic compounds through qualitative analysis involving the irradiation of sample with a continuous stream of light to acquire the absorption spectra. The  $\mu$ -FT-IR method is suitable for carefully analysing the components of each sample. Ten analytical samples were sorted randomly from each classification size, and 700 samples were analysed for each ID.

## 3 Results

### 3.1 Observations

Fig. 3 shows images of dust sample of each classification size and Fig. 4 shows images of the shapes of microplastics observed using a microscope. The classified house dust was found to be mixed with fibrous (microfiber) and powdery dust in all classified sizes. As the classification size decreased, the density of the

fibrous particles decreased, and many powdery particles were observed. For a relatively larger classification size (500  $\mu$ m or more), the fibrous substances existed in a tangled state, as shown in the figure. The fibrous, the fibrous, powder, and fragment shapes were observed as the shapes of microplastics.



**Fig.1** The map of surveyed regions<sup>7)</sup>

**Table 1** Target houses information

Region	ID	Prefecture	Structure
Kanto (KT)	KT1	Saitama	W
	KT2	Saitama	W
	KT3	Kanagawa	W
	KT4	Tokyo	RC
Chubu (CB)	CH1	Nagano	S
	CH2	Nagano	W
	CH3	Nagano	RC
	CH4	Nagano	S
Tohoku (TH)	TH1	Akita	W
	TH2	Akita	W
	TH3	Akita	W
	TH4	Akita	W
Kansai (KS)	KS1	Osaka	S
	KS2	Osaka	W
	KS3	Osaka	S
	KS4	Osaka	S

### 3.2 Qualitative analysis using $\mu$ -FT-IR

Fig. 5 shows the sample preparation for  $\mu$ -FT-IR analysis using KBr plate method. The  $\mu$ -FT-IR analysis results of the samples prepared using the KBr plate

method are shown in the Fig. 6 to Fig. 8. The component proportions of dust for each region are shown in the Fig. 6. The abbreviated symbols for chemical substances show in Table A1. The component analysis results indicate the component names in microplastics, the substances other than plastics are indicated as 'Others', and the substances for which the components could not be identified are indicated as 'Unknown'. Cellulose was the most abundant component in all regions at 45.4–61.8%. Polymer was the second most abundant at 20.7–35.4%. classified. Among polymers, polyethylene terephthalate (PET) was the most abundant at 54.8–72.2% in total polymers, followed by polyester (PEs), polyacrylonitrile (PAN), and Polyvinyl acetate (PVAC), and these proportions are approximately 93% of the total polymer. Polymers were detected about 20 different components in total. Fig. 8 shows the proportion of polymers of each ID. PET was the most common in all ID, approximately 40–85%. Polymers were 17–29% and it were confirmed that various resins existed as a whole. Although there was variation in the ingredients for each ID, the majority was in order of PET, PEs, and PAN. 14 types of polymer components were detected in all IDs.

#### 4 Conclusion

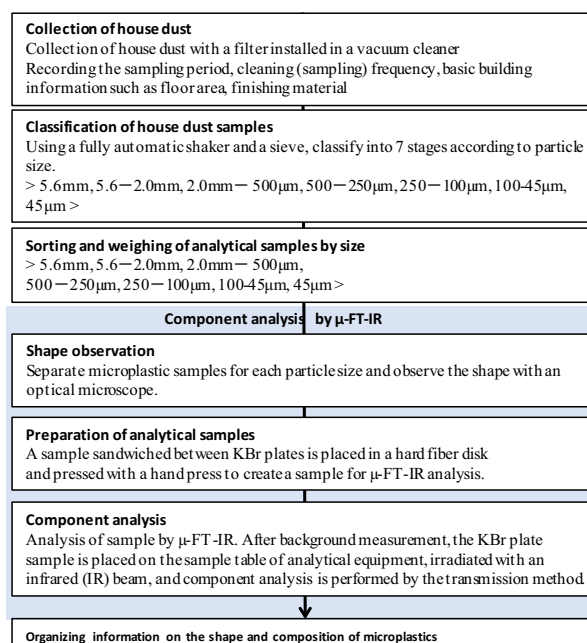
It was confirmed that various polymers exist as microplastics in the indoor environment of four regions in Japan. We observed the morphology of the collected house dust and confirmed that it could be roughly classified into fibrous and particulate forms. The surface of fibrous substances was observed smooth and rough surfaces. The fibrous (microfiber) and powdery dust were mixed in all classified sizes. 10 to 20 kinds of components were detected in the dust sample. In addition to the house dust settled on the floor, we plan to investigate the suspended dust in the air. A large fraction of microplastics was present in fibrous and particulate form in the indoor samples of all houses. Identifying the limits of occurrence should be investigated in future studies.

#### Appendix

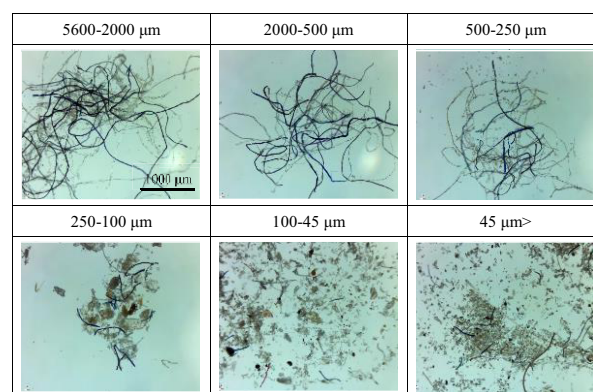
Table A1 shows the abbreviated symbols for chemical substances.

**Table A1** Abbreviation of polymers

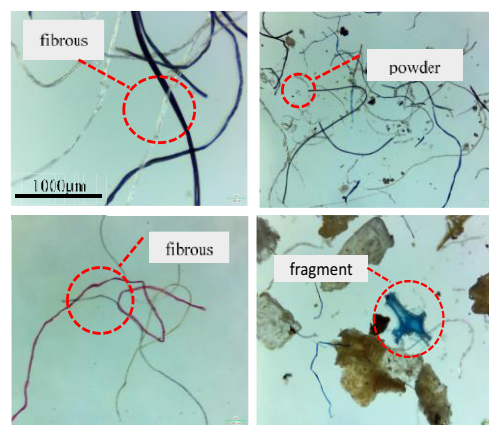
Abbreviation	Compound name
PA	Polyamide
PAM	Polyacrylamide
PAN	Polyacrylonitrile
PBT	polybutylene terephthalate
PE	Polyethylene
PEs	Polyester
PET	Polyethylene terephthalate
PP	Polypropylene
PVAC	polyvinyl acetate



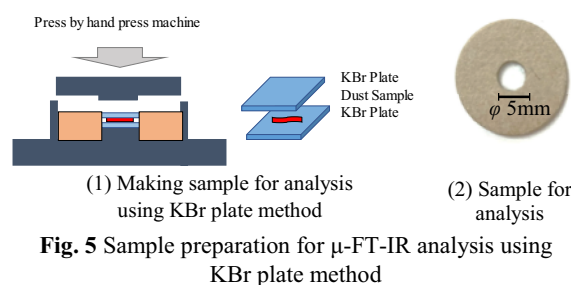
**Fig.2** Sampling and analytical protocol



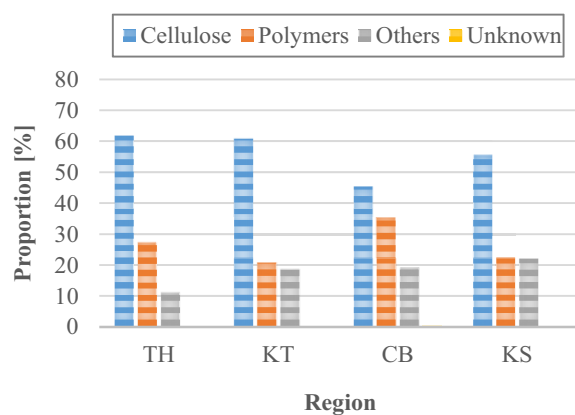
**Fig. 3** Dust sample of each classification size



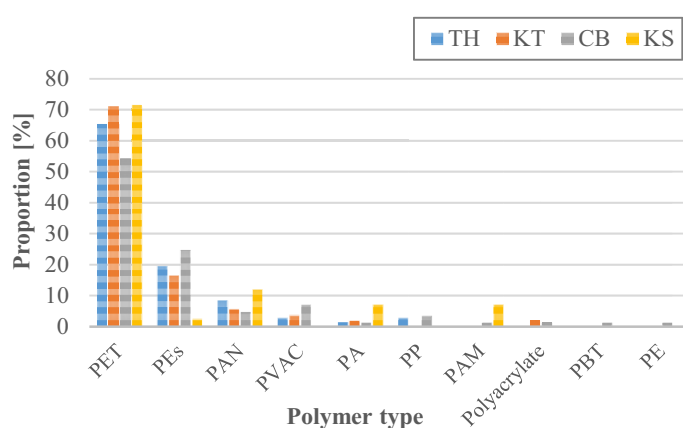
**Fig. 4** The shapes of microplastics



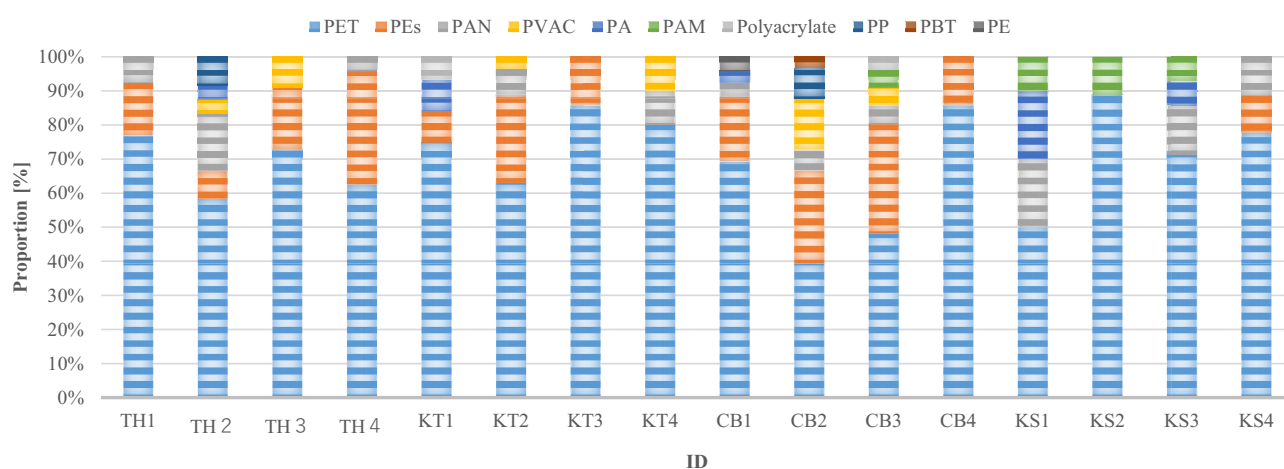
**Fig. 5** Sample preparation for μ-FT-IR analysis using KBr plate method



**Fig. 6** Proportion of the components of dust



**Fig. 7** Proportion of the components of polymers



**Fig. 8** Proportion of polymers of each ID

## Acknowledgments:

This research was partially funded by the Japan Society for the Promotion of Science (JSPS) Grants-in-Aid for Scientific Research (KAKENHI) (grant numbers JP 21H04585) and Health Labour Sciences Research Grant (JP 21KD2002). We received assistance in the  $\mu$ -FT-IR analysis from the Bio-Nano Electronics Research Centre at Toyo University. We would like to express our profound gratitude for their help.

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