Children's playgrounds contain more microplastics than other areas in urban parks


Department of Civil and Environmental Engineering, University of California at Los Angeles, CA, USA
Moore Institute for Plastic Pollution Research, Long Beach, CA, USA

ABSTRACT

Children spend many hours in urban parks and playgrounds, where the tree canopy could filter microplastics released from the surrounding urban hotspots. However, the majority of children's playgrounds also contain plastic structures that could potentially release microplastics. To assess if the children's playgrounds pose a higher exposure risk than other places inside the park, we evaluate the extent of microplastic contamination in the sand, soil, and leaf samples from 19 playgrounds inside urban parks in Los Angeles, CA, USA. The average microplastic concentration in sand samples collected inside the playground was 72 p g−1, and >50 % of identified plastics were either polyethylene or polypropylene. Microplastic concentrations inside the playgrounds were on average >5 times greater than concentrations outside the playgrounds in the park, indicating that children playing within the playground may be exposed to more microplastics than children playing outside the playground in the same park. By comparing the microplastic composition found inside and outside the playgrounds with the plastic composition of the plastic structures in the playground, we show that plastic structures and other products used inside the playgrounds could contribute to elevated microplastic concentration. The population density was slightly correlated with a microplastic concentration in the park soil but did not correlate with microplastic concentration inside the playgrounds. Therefore, playgrounds in urban parks may have microplastic exposure risks via inhalation or ingestion via hand-to-mouth transfer.

1. Introduction

Microplastics are ubiquitous throughout the natural and built environments, and urban areas often serve as hotspots for microplastics due to...
the increasing use of plastic products and the release of secondary microplastics from plastic wastes (Golwala et al., 2021; Song et al., 2017). Within urban areas, soil (Koutnik et al., 2021b; M. Zhang et al., 2022a), water (F. Liu et al., 2019b; Yu et al., 2022), roads (O’Brien et al., 2021; Yukioka et al., 2020) and waste processing sites (He et al., 2019; Yadav et al., 2020) are often found to contain high concentrations of microplastics due to their proximity to the source of microplastics. Microplastics are found at high concentrations in indoor environments due to their release from plastic-containing materials such as carpets and other products (Yao et al., 2022). In contrast, the concentration is expected to be lower in outdoor environments, where the microplastics can be diluted during transport via air. In particular, green spaces such as parks in urban areas would contain fewer microplastics due to the filtration of airborne microplastics by tree canopy (Allen et al., 2021; Van Stan et al., 2021). However, most children’s playgrounds in the parks contain large plastic structures such as slides, playhouses, rides, and rubber flooring. These plastic structures could release microplastics into the sand or soil and make the playground a source of microplastic contamination relative to other areas inside the park. Although children often spend most of their outdoor time in these areas (Mulryan-Kyne, 2014), the concentration of microplastics in different areas inside urban parks has not been measured. Recently, microplastics were found in human blood and lungs (Campanale et al., 2020; Street and Bernasconi, 2021). Thus, it is important to compare the microplastic concentrations in designated playgrounds with other areas inside parks in urban areas so that exposure can be assessed.

Microplastics in parks could be accumulated by different processes. First, microplastics can be transported from surrounding areas by water and wind (Piñon-Colin et al., 2020; Rezaei et al., 2019). Parks are typically located in elevated areas to minimize flooding risks. Thus, the runoff would not flow into the playground. This limits the number of microplastics accumulated in these areas by surface runoff. In contrast to water, wind can transport microplastics from different parts of the urban area across any geographical boundary and deposit them on playgrounds or leaves in the tree canopy. The deposition of microplastics in any urban area thus depends on the wind profile in that region. The urban canopy could intercept wind and inhibit its ability to carry microplastics and other dust, resulting in atmospheric deposition of the microplastics (Allen et al., 2019; Huang et al., 2021; Kleijn and Fischer, 2019). However, microplastics deposited by wind into playgrounds have not been compared to those deposited outside the playgrounds. As leaves contain high concentrations of microplastics in urban areas (Koutnik et al., 2022b; Li et al., 2022), concentrations on leaves in trees within and outside the playground boundary can be used to compare the deposition of microplastics via wind.

The major source of microplastics in playgrounds could be the built-in plastic structures such as slides, plastic carpet flooring, and houses or roof. Additionally, children bring toys and other plastic products into the sandpits in the playground. Abrasion of these plastic products with sand could release microplastics (Ren et al., 2020; Sipe et al., 2022). Furthermore, many plastic structures in playgrounds are directly exposed to sunlight, which can accelerate the degradation of their plastic surface (P. Liu et al., 2020b; Ren et al., 2021). Consequently, high concentrations of microplastics could be released from these structures by physical and biochemical weathering (Duan et al., 2021). Yet, no study to date has examined the extent of microplastics released from these structures and their contribution to the net accumulation of microplastics in children’s playgrounds in urban parks.

The objectives of this paper are to compare the concentration of microplastics inside and outside designated children’s playgrounds within urban parks and identify the dominant source of microplastics present in the playground. We hypothesize that the release of microplastics from built-in plastic structures inside the playgrounds, not the atmospheric deposition, is the dominant pathway of microplastic accumulation in the playgrounds, and children playing inside the playground would have higher exposure to microplastics than children playing outside the playground within the same park. To test the hypotheses, we collected surface and leaf samples within and outside playgrounds in 19 parks in Los Angeles, USA, and compared the concentration of microplastics and their abundance. A comparison of the concentration of microplastics within and outside the playground could help determine whether children might be exposed to more microplastics playing in certain areas than others inside urban parks.

2. Method

2.1. Playground locations

To compare microplastic concentration from different areas within urban parks, we collected sand or soil, and leaf samples from 19 playgrounds in locations with different population densities across Los Angeles County, USA, between January 25th and February 15th, 2022. The last rainfall in Los Angeles was recorded on January 18th. According to the 2020 census, the population densities near the playgrounds ranged between 0.9 and 20,378 people km\(^{-2}\) and were categorized into two groups: over 4000 (9 playgrounds) and under 4000 people per km\(^{-2}\) (10 playgrounds). The concentration data were also fitted with population density to evaluate if there is a correlation between population density and the concentration of microplastics in different areas inside the park.

2.2. Sample collection

Soil and sand samples were collected inside and outside of the playgrounds within the urban parks using a stainless-steel spatula. Composite samples consisting of >10 spoons of media (2–3 g per spoon) were collected at random spots inside the playground, at the boundary of the playground, and outside the playground within the park, resulting in three composite samples per given location. The inside sample was collected either from the playground’s sandbox or the playground itself. The boundary sample was collected from the perimeters of the playground, and the outside sample was collected 50 to 100 m away from the boundary of the designated playground within the park. The composite samples were mixed inside an aluminum foil packet and labeled. The spatula was thoroughly cleaned using deionized (DI) water and wiped between sampling to prevent cross-contamination.

To analyze the atmospheric deposition of microplastics in areas within the park, 5–10 leaves were sampled directly from trees at an elevation of 2 m from varying plant species both inside or directly around the playground, and 50–100 m away outside the playground. Leaves were plucked by holding them by the stem with a hand or tweezers and then cutting them from the tree with clean metal scissors. Leaves were classified as either inside or outside samples and were wrapped individually in aluminum foil to prevent cross-contamination.

To compare the chemical composition of source plastics released from plastic structures in playgrounds with the microplastics found on the ground, small pieces of plastic were scraped off the various plastic structures including slides, small houses, and rubber floors in the play areas, and collected into an aluminum foil for identification.

2.3. Extraction and quantification of microplastics from soil and sand samples

Microplastics were isolated from sand and soil samples following the method described earlier (Koutnik et al., 2022b). Briefly, to separate debris from microplastics, 1 g of each composite sample was mixed with 40 mL of 1.6 g mL\(^{-1}\) potassium iodide (KI, Thermofisher Fisherbrand, P410–500) solution and centrifuged at 5000 rpm for 30 min to settle heavier soil particles and isolate lighter (density < 1.6 g cm\(^{-3}\)) particles including microplastics. Centrifugation has been used to separate particles based on density, which is not expected to break plastic suspended in fluid due to limited abrasion (Gnuse et al., 2022). Our preliminary study with centrifugation did not result in the breaking of plastic particles, likely due to the durability and plasticity of particles. The supernatant was vacuum filtered to trap floating debris on a 24 mm glass fiber filter paper with a 1.2 µm pore size (Thermofisher Scientific, 09–804-24C). The filter was then placed...
inside a glass Pyrex petri dish, covered with a glass cover, and left to dry for at least two hours. A method blank was processed every day by using DI water in all the steps to estimate any microplastics introduced from the materials used during the extraction steps.

The concentration of microplastics on the filter paper was quantified by dyeing the filter with Nile Red, capturing an image of fluorescent particles with a smartphone-based fluorescence microscope. The details of the method are described in the original work (Leonard et al., 2022). This method has previously been used to assess microplastic concentration in urban stormwater infrastructures (Koutnik et al., 2022b) and in a laboratory study on microplastic transport in biofilter (Koutnik et al., 2022a). Briefly, filters containing microplastics on a glass petri dish were dyed with 0.17 mL of 0.5 µg mL⁻¹ Nile Red in chloroform solution and air-dried with a glass cover for 24 h in the fume hood. Dried filter membranes were transferred onto glass slides, covered with a glass coverslip to eliminate dust deposition, and imaged using a smartphone-based fluorescence microscope. The method could detect microplastics as small as 10 µm due to a large field of view of 490 mm², and have limitations associated with the selectivity of Nile Red to bind plastic polymers.

2.4. Concentrations of microplastics on leaves

To quantify the number of microplastics per unit surface area of leaves, collected leaves were cut using metal scissors into a rectangular shape so that their area can be estimated. Debris from the leaves was washed with 100 mL of DI water into a glass beaker, and the microplastics suspension was vacuum filtered onto a 24 mm G4 glass fiber membrane. As dust mostly contains lightweight materials, the KI solution was not used, which is typically used to remove a substantial amount of soil or heavy particles that could obscure the view of microplastics under the microscope. The filter membranes were then dyed with Nile Red and analyzed for microplastic concentration. To evaluate if leaves can release organic residues that can be falsely interpreted as microplastics, we collected dust from pre-washed leaves and followed the same process, and found microplastics below the detection limit.

2.5. Microplastic characterization

To examine the size distribution of microplastics and their abundance by polymer types, microplastics isolated from leaves and sand samples using KI solution were vacuum filtered on a nitrate cellulose filter and scraped onto a gold-coated slide for Fourier Transform Infrared spectroscopy (FTIR) analysis. Specifically, 3 g of inside playground samples, 3 inside leaves, and 3 outside leaves were analyzed using FTIR. The large pieces of scraped microplastics from playground structures formed a composite sample and were also analyzed for their composition. Microplastics on the gold slides were characterized for their size distribution, shape, and polymer types using FTIR analysis (Thermo Scientific Nicolet iN10). The FTIR microscope was used in the reflectance mode using the particle analysis wizard included in the PICTA software following a similar method as described by Brahney et al., 2020 (Details in Supplementary Materials). The FTIR microscope can identify the size distribution of microplastics larger than 20 µm based on the image analysis of particles spread on a 1 cm² area of the slide. When comparing sample spectra to spectra databases, 60 % match criteria were required to identify the particle. Individual sample spectra were then visually examined against their database match to confirm the identification. If particles were matched to a generic, the spectra of broad category of plastics—such as polyolefin, which can refer to as either polyethylene or polypropylene—were analyzed for a second time using OpenSpecy, an open-source software developed to allow researchers to match their spectra to the existing library (Cowger et al., 2021). All “cellulose nitrate” or “cellulose” spectra were attributed to the filter, based on a blank filter FTIR characterization, and removed from the analysis.

2.6. Quality control

During the lab work, clothing made from natural materials was worn to prevent cross-contamination of the samples. For sampling, storage, and processing, pre-washed glass, and aluminum containers were used. All clean glassware and containers were rinsed with DI water three times. The DI water was analyzed following the methodology used for supernatant analysis for possible microplastic contamination. At all times when samples were processed, dried, or stored they were covered by glass covers or aluminum foil. Only for a minimal time (< 1 min) during pouring and vacuum filtering, samples were left out open. Composite samples were analyzed in triplicates to assess the heterogeneity in the samples based on the standard deviation over the mean of triplicate measurements. No field blanks were collected as the samples were taken from the surface using clean tools. We have performed laboratory blanks to account for any cross-contamination. A method blank was run during each day of analysis, following the same lab procedure during sample analysis. The mean laboratory blank for soil samples was 3 pieces and the mean for leaf samples was 1 piece. The mean of laboratory blanks for each method was subtracted from the measured concentration of samples to account for any microplastics introduced from any material used. The methodology has an average recovery rate of 93.7 % ± 13.7 %, a human processing variation of 6.8 % of the mean, and a sample processing variation of 9.1 % (Koutnik et al., 2022a). Therefore, the total maximum error for each of the microplastic measurements was estimated to be 22.2 %.

3. Results

3.1. Microplastic concentrations in different areas inside the park

Analysis of microplastic concentrations in sand and soil samples collected inside, on the boundary, and outside the designated playgrounds in urban parks reveals that microplastic concentration inside the playground is >5 times the concentration of microplastics outside the playground (Fig. 2). The average microplastic concentration in sand samples collected inside the playground was 72 p g⁻¹. The concentration decreased to 42 p g⁻¹ near the boundary and 13 p g⁻¹ outside the boundary. The difference between concentrations inside and at the boundary is not statistically significant (p-value = 0.59). However, the concentration outside the playground was significantly different when compared with both areas inside (p-value = 5.5 × 10⁻⁶) and near the boundary (p-value = 4 × 10⁻⁵) (Fig. 1).

3.2. Size and abundance of microplastics within the park

A comparison of the size and abundance of microplastics within and outside the playground reveals that the size, shape, and type of microplastic polymer found inside the playgrounds were slightly different from those found outside the playground (Fig. 3). Inside the playgrounds, both sand and leaf samples had PE and PP as the most commonly found microplastic polymer types, meanwhile leaves from outside the playground had 83 % PP and no PE microplastics. Based on FTIR analysis of plastic scraps from the built-in plastic structures in the playgrounds, they are mainly made up of PE and PP (Table S1). A similarity of dominant plastic polymer types used in structures and microplastic polymers found in sand and on leaves inside the playground suggests that the plastic structures were a possible source of microplastics inside the playground. Up to 60 % of microplastics in the sand and 73 % of positively identified microplastics on the inside leaves are PE and PP, and they could be released from plastic structures within the playground. Based on FTIR analysis, 25 % of microplastics found in sand samples were fibers- plastic fragments with length-to-width ratio >3 (Cole, 2016; Wylie et al., 1993). The fiber fraction on leaves samples inside and outside the playground were 9 % and 17 %, respectively. The results indicate that the dominant shape of microplastics within parks is fragments, which are typically produced by physical abrasions or chemical weathering. This is in contrast with many previous environmental studies that found a higher concentration of fibers than fragments (Dodson et al., 2021).
(2020; Liu et al., 2018). The fiber shape was confirmed using an FTIR microscope following the method described elsewhere (Brahney et al., 2020). Thus, the cause of the lower concentration of fiber in our sample is unknown.

>50% of microplastics found in all locations have sizes larger than 100μm. The majority of pieces both on leaves and in the sand were 100–300μm indicating large microplastics can be resuspended or transported by wind. However, leaves contained a greater percentage of the smallest identifiable microplastics (<50μm) indicating smaller microplastics are preferentially transported or accumulated on the leaves. The FTIR microscope used in the study could not reliably detect microplastics smaller than 20μm. Thus, the size distribution reported here could have underestimated the concentration of microplastics smaller than 20μm.

3.3. Microplastic deposition on leaves in parks

The microplastic concentrations of 91 analyzed leaf samples ranged between 0 and 6.5 p cm⁻² (Fig. 4). The concentration was significantly higher (p-value < 0.05) on leaves (2 p cm⁻²) collected from trees outside the playground compared to leaves inside the playground (1.3 p cm⁻²).

3.4. Population density effect on microplastic concentration in the parks

An increase in the population density significantly (p-value < 0.05) increased the microplastic concentration in the soil outside the playground (Fig. 5). Although population density appears to increase the concentration of microplastics inside the playground, this increase in concentration was not significant (p-value > 0.05). Microplastic concentrations in samples collected in areas of high population density varied more widely than their concentrations in samples collected in areas with lower population density. This high variability meant the difference in microplastic concentrations between locations with low and high population density was insignificant (p-value > 0.05), both for samples collected inside and boundary samples, even though the average concentrations in samples with higher population density were higher. The concentration of microplastics in the boundary is slightly higher than that outside, indicating the playground has contaminated adjacent areas.

4. Discussion

4.1. Cause of elevated microplastic concentration in playgrounds

Microplastic concentrations were found to be the highest inside the boundary of playgrounds, indicating that children playing inside the playground could be exposed to more microplastics than children playing outside the playground in the same park (Fig. 2). The concentrations decreased from inside to the boundary to outside the playground. Although the method has similar shortcomings to other studies that used Nile Red (Devalla et al., 2019; Erni-Cassola et al., 2017; Shim et al., 2016), where the presence of a certain form of organic carbon could create a false positive, using the same method permits a broad comparison of concentrations inside and outside playground in the park. As the samples outside had more organic carbon than samples inside the playground, there could be more false positives in the samples collected outside the children’s playground area. Thus, the concentration difference between samples collected inside and outside designated playgrounds could be smaller than what is reported in this study.

We attribute the result to the release of microplastics from built-in plastic structures and possibly plastic toys and other materials within the playground, not the atmospheric deposition of microplastics from surrounding

Fig. 1. Map of Los Angeles with sampled playground locations. Playgrounds in areas with a population density higher than 4000 individuals km⁻² are shown in circle, and playgrounds with a population density below 4000 individuals km⁻² are shown in triangle.
areas. The analysis of the playground material revealed the source plastic polymers were predominantly PE and PP, which matched with most abundant microplastics found inside the playground and on the leaves. In addition, children often wear synthetic clothing (Dris et al., 2016; Y.-Q. Zhang et al., 2022b) and bring and play with plastic toys, which can also release microplastics due to mechanical abrasion with sands (Ren et al., 2020; Song et al., 2017). Even though most of the sampled playgrounds were located inside parks and green spaces, they still lacked shade due to limited vegetation or urban canopy cover. Therefore, the plastic structures were exposed to UV radiation and could be weathered at a high rate (Liu et al., 2022; Song et al., 2017; Sørensen et al., 2021), especially since LA has perennial sunshine.

Microplastics could be transported by wind over long distances (Brahney et al., 2020; Bullard et al., 2021) and thus are expected to be released from urban sources and deposited on the playgrounds. Our data shows that microplastic concentrations on leaves outside the playground were greater than the concentration on leaves inside the playgrounds within the parks. The result indicates that dry-vertical atmospheric deposition contributed to a small fraction of microplastics accumulated inside the playground and that resuspension of microplastics accumulated in the playground has limited contribution to the microplastics detected on the leaves in the playground. In contrast, hand-to-mouth transfer of microplastics could be the dominant exposure pathway during children’s play in the sandpit. This is particularly plausible because the dominant size of microplastic observed in the playground is above 100 μm. These large microplastics are less likely to be transported into the lung by inhalation compared to microplastics <10 μm. However, the method used in this study is incapable of detecting and quantifying microplastics <10 μm. As these airborne microplastics can also serve as vectors for contaminants (Borthakur et al., 2021; Chen et al., 2020), future studies should develop methods to identify smaller microplastics in samples retrieved from playgrounds in urban parks.

4.2. Comparison of the characteristics of microplastics on the ground and leaves

Microplastics on the ground inside the playground had different polymer types, and size characteristics compared to the microplastics found on the leaves inside the playground (Fig. 3), indicating that some plastic polymers could be preferentially transported by wind. Specifically, the microplastics identified in samples from inside the playground had a much more diverse range of polymers. However, all microplastic polymer types (PE and PP) identified on leaves inside the playground matched that of plastic polymer types used in the structures inside the playground. Surprisingly, leaves outside playground boundaries contained no PE microplastics, suggesting that PE microplastics found inside the playground could originate from the plastic structures in the playground. However, as PE is one of the most commonly used plastic polymers, PE microplastics can also come from the common materials used inside the play area such as toys, food containers, clothes, and many other plastic products brought by children to the playground (Gaylarde et al., 2021). FTIR-ATR analysis on a large piece of plastic from the floor mat from the play area matched rubber spectra, indicating many pieces not identified by FTIR in reflectance mode might be rubber. Future studies should conduct much more highly detailed FTIR characterization (size, color, shape) on a site-to-site basis to more accurately confirm the source of playground plastics are the playground structures themselves.

Microplastics on the leaves outside playground boundaries are an indicator of microplastics deposited by the atmospheric dry deposition, whereas microplastics on the leaves inside playgrounds are an indicator of both atmospheric deposition, wind, and resuspension of microplastics from sand within the playground. Plants species have been proven to capture atmospheric microplastics (Li et al., 2022; K. Liu et al., 2020a), but the source of those atmospheric microplastics has not been confirmed. In this study, we determined that up to 73% of microplastics found on the leaves inside the playground may be sourced from plastic materials (structures, toys, litter) within the playground. When the source plastic pieces were analyzed using FTIR, we were only able to identify 31 out of 77 pieces analyzed as polymers with matches above 60%. This demonstrates that many of the particles with lower matches could still be...
Most of the microplastics detected in our samples are non-fibrous, which agrees with past studies of dust samples (Dehghani et al., 2017; Yukioka et al., 2020). However, many of the previous studies (C. Liu et al., 2019a; Su et al., 2020) also found that fiber shape was more common in dust samples. We attributed this difference to the source of secondary microplastics found in the parks in Los Angeles. The fibers are generally created from cloths, carpets, and other plastic materials (Dris et al., 2016). Our results indicate that most of the microplastics found in our study may originate from different sources such as the built-in plastic structures, toys, and litter in and around the playgrounds. Future studies should explore the shape of microplastics and possible sources of secondary microplastics in the region.

4.3. Population density effect on microplastic exposure

Population density appears to have a very weak correlation (R² < 20%) with microplastic concentrations inside the playground (Fig. S3), likely because playground usage is not correlated with population density or the microplastic concentration in the playground is more affected by the release of microplastics from built-in plastic structures, toys and litter in the playground than atmospheric deposition from populated areas. Other factors that could influence microplastic concentration in the playground are: the size of the park or distance from nearby residences or sources, vegetation coverage relative to total park areas, and surface area of plastic playground equipment relative to the area of the playground also influence. Future studies should examine their effects. The atmospheric deposition of microplastics has been reported all over the world (Abbasi and Turner, 2021; Fang et al., 2022; Liao and Chen, 2021), even in remote areas (Allen et al., 2019; Brahney et al., 2020; Evangeliou et al., 2020; Zhang et al., 2021). Soil samples outside the playground (at least 100 m away) were mostly collected from open areas and parks. These outside samples could serve as indicators of the microplastic accumulation and deposition in the parks. Population density could affect the outside soil microplastic concentrations due to a proportional increase in the human consumption of plastic products and the generation of plastic wastes that directly release microplastics into urban environments. However, microplastics created in densely populated areas are not confined and can still migrate across geographical boundaries to lower population density areas via wind. Even though we sampled locations with a range of population densities, Los Angeles is still a relatively highly urban and densely populated area. While our study found a weak correlation of microplastic concentration with population density, more studies are needed to compare microplastic concentration in areas with more diverse population densities and plastic uses.

In highly urbanized regions, parks are often the only outdoor space where children spend a long time. Although outdoor playtime for children has been declining over years in highly urbanized regions, children still spend a longer time in parks compared to any other outdoor space in urban areas (Bao et al., 2021). The results of our study demonstrate that playgrounds could be a significant source of microplastics compared to other areas within urban parks, potentially due to the release of microplastics from plastic structures within the playground. Another source of microplastics in parks could be compost and biosolids (Koumik et al., 2021a; Vithanage et al., 2021), which are typically applied to maintain vegetation in parks. Additionally, microplastics found in parks could be enriched with pollutants such as lead, BPA, cadmium, phthalates, or other chemical additives found in children’s toys or playground structures (Becker et al., 2010). Thus, it is essential to quantify the concentration of these pollutants on the microplastics released and accumulated in children’s playgrounds in urban parks.

5. Conclusion

Analyzing microplastic concentration in different parts of 19 parks in Los Angeles, we confirmed that microplastic concentration in children’s playgrounds could be five times more than that in any other areas within the boundary, and outside the playground within the sampled parks. Wilcoxon rank-sum test was performed (R version 4.0.0), with * indicating a p-value <0.05 and ns indicating no statistically significant difference.
the same park. The most common type of microplastics found on samples inside playgrounds (e.g., PE and PP) matched with the polymer composition of the plastic structures inside the playground, indicating many of the microplastics accumulated in the playground could come from the built-in plastic structures. Another source of microplastics in the playground could be food wrappers, toys, synthetic clothing, and those that are transported from urban hotspots by the wind. A comparison of the size of microplastics and their polymer types inside and outside the playground reveals that plastic structures and plastic materials brought to the playground rather than microplastics transported from urban hotspots outside playgrounds are likely the major sources of microplastics found in the playgrounds reveals that plastic structures and plastic materials brought to the playground could be much lower than that in some indoor environments where plastic materials such as furniture fabrics, clothing, foam cushioning, and plastic carpets could release a high amount of microplastics.

CRediT authorship contribution statement

Vera S Koutnik: Conceptualization, Methodology, Data Collection, Formal analysis, Writing - Original Draft.

Jamie Leonard: Review, Editing.

Lea A. El Rassi: Data Collection

Michelle M. Choy: Data Collection

Jaslyn Brar: Data Collection, FTIR analysis

Joel B. Glassman: Data Collection

Win Cowger: FTIR analysis, Editing

Sanjay Mohanty: Visualization, Writing - Review & Editing.

Data availability

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data contains the description of parks (Table S1), FTIR methodology for identification of microplastics, the abundance of plastic polymer types found in plastic structures in the park (Table S2) and their FTIR spectra (Figs. S1 and S2), an image showing the size or shape of microplastics found in playgrounds (Fig. S3), and correlation between population density and microplastic concentrations in different parts of parks (Fig. S4). Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2022.158866.


