Abstract: Plastic pollution has become a growing concern for environmental and human health in recent years. Currently, research suggests that soil compartments might be highly contaminated, with compost being one of the major sources for plastic contamination, especially at reduced sizes. In Geneva, microplastic contamination has already been evaluated in industrial compost but not yet in field-side compost. Therefore, this work focuses on the evaluation of concentrations and the characterization of microplastic particles (MPs) in field-side compost in Geneva. Four different field-side composts were sampled in Geneva and sieved with sizes ranging from >5 mm to 0.5 mm. The MPs were visually sorted when possible, and the smaller ones were treated by digestion and density separation processes. All of the MPs were analyzed with infrared spectroscopy. The results (sizes > 5 mm to 1.25 mm) reveal concentrations between $195 \pm 64$ and $1315 \pm 375$ plastic particles/kg of compost and the presence of conventional plastics in every compost. MPs were present in almost every size fraction for the four composts, and the origin of waste seemed to influence their concentrations. Indeed, composts free from organic household waste had lower concentrations than the ones accepting that kind of waste. Littering and waste still wrapped in plastic were also noticed for the composts with higher concentrations of MPs. The characterization results highlight the variety of plastic types among the composts, mostly represented by PE (polyethylene), PVA (polyvinyl alcohol), PP (polypropylene), and DAIP (polydiallyl iso-phthalate) in general but also specific contamination by PEMA (poly ethyl methacrylate) for only one of the composts. Further work is needed to evaluate the distribution of MPs according to their size or the types of waste used in composting, especially the potential degrading conditions of plastics, to mitigate their presence in composts.

Keywords: microplastics; compost; contamination; ATR; FT-IR

1. Introduction

With production worldwide reaching around 400 million tons in 2022, plastics are mostly used for single-use packaging, unfortunately ending up in different environmental compartments [1,2]. Fragmentation or embrittlement processes make plastics available for organisms to ingest or absorb, including plants, with some particles even reaching sizes small enough (nanoplastics) to pass through cell walls [3–6]. As a result, microplastics (MPs) and nanoplastics (NPs) have important consequences for terrestrial ecosystems, their responses to this contamination, the services they provide, and the organisms living in them [7].

The effects of MPs and NPs on soil organisms can be direct, affecting their mobility, causing wounds, and disrupting their digestive or respiratory systems if ingested or inhaled, including the release of potential toxic additives or heavy metals attached to the plastics [8–11]. The effects can also be indirect by changing the characteristics of the environment like water retention capacity; the porosity, structure, and texture of soil; pH; and electroconductivity [3,12–15]. Several studies observed their impacts on
earthworms, which can transport MPs into their guts through the soil, and reported reduced growth and reproductive rates, higher mortality, changes in intestinal microbiota, and skin lesions depending on the type of plastic, its exposure concentration, and the worm species [3,16–19]. Playing an important role in the food chain, worms can transfer plastic contamination to higher levels in the food web. Also, after digestion by worms, MPs can be fragmented into smaller sizes, rendering them available for ingestion by smaller microorganisms, such as microarthropods, with similar effects on them [8,20]. With such various effects according to their type, shape, composition, and size—especially nano sizes able to pass through cell walls—MPs and NPs can affect the environment on a large scale, like in nutrient cycles, soil fertility, microbial communities, and the entire food chain, reaching humans [6,11,12,20–23].

The impact of MPs also depends on the organism and how it is exposed to MPs, and humans are no exception [24]. Studies have shown that water and food intended for human consumption can be contaminated by plastic because of leaching from containers, production processes, or other items [25–28]. Senathirajah et al. [29] estimated that humans ingest around 0.1–5 g of plastic (size < 1 mm) per week. Usually, 90% of ingested micro and nanoparticles do not stay in the human body and are evacuated in the feces [23,30], but some stay in the human body, as shown by Leslie et al. [31], who observed a mean concentration of plastic particles at 1.6 µg/mL in human blood.

Exposure to plastic may cause several health issues, but the literature is still scarce about the direct effects on human health that are solely provoked by plastic itself or certain monomers comprising it, as listed by Lithner et al. [32]. However, plastics can be vectors for other compounds like additives, pesticides, heavy metals, medicine, and persistent organic pollutants, which concern human health and can be transported by plastics mainly through sorption processes [33–35]. Those pollutants, as additives or sorbed on plastic surfaces, can be clearly linked to human health issues such as cardiovascular, weight (obesity), diabetes, cancer, and hormonal problems—for example, endocrine disturbance and developmental and reproductive issues [29,36–40]. The detrimental impact on organisms vary according to the composition of the monomers in plastic, as well as plastic size, shape, and the additives potentially carried with them [5,32,41–43]. The additives accompanying the plastics can be toxic and carcinogenic, leading to cancer and disruption of the reproductive system [44].

Most studies have been focused on the marine environment, but lately, soil has been revealed as a potential storage of plastics that is even more polluted than the seas [7,45–47]. Horton et al. [11] even estimate that the amount of plastic waste in the EU released on land is 4–23 times greater than that released in the ocean. In agriculture, the use of wastewater, sewage sludge, and compost from organic waste has a role in fertilization, improvement of the soil structure, and the reuse of waste [48,49]. Unfortunately, this can bring a significant input of MPs per year into the soil. Bläsing and Amelung [48] report compost bringing between 7 and 35 t/ha/year of MPs, while Okoffo et al. [50] estimates that in Europe, the input of plastic particles to the soil is between 63,000 and 430,000 t/year using biosolids. Those inputs are without accounting for littering or practices like plastic mulching, intended, for example, to increase the temperature or water-retention capacity of the soil [51–55].

Once in the environment, MPs are constantly transported through the environmental compartments by air, atmospheric deposition, rivers, water runoff, ocean currents, erosion, and biota, either by bioaccumulation or bioturbation [5,7,12,56–61]. However, the soil is less subject to MPs transport, and the soil’s preserving conditions, especially in the deepest layers, protect MPs against UV and other degradation processes, increasing the stock of plastic into the soil for a long time [62–69]. The physico-chemical properties of plastics often allow them to resist full degradation processes and accumulate in the environment or in the biota by bioaccumulation, as shown by McMullen et al. [70], even if their true persistence is yet to be better understood [12,71].

These latest studies raise awareness among the scientific community and the population [72], including in Geneva, where concentrations of around 4473 MPs per 100 g
of compost were found in an industrial facility [73]. Even if efforts are made to sensitize the population about sorting and promoting compostable plastic bags for the collection of organic domestic wastes, a lot of unwanted materials remain [74]. In addition, the compostable plastics degrade in industrial composting conditions regulated by the standard EN 13432, which are not always met in field-side composting [75,76]. In Geneva, field-side composting processes around 7000 t/year of green wastes, which produces around 4000 t/year of compost used on crops and cultures [77,78].

Owing to the lack of data and knowledge on the nature of plastics and their concentrations in the different types of composts, especially MPs or NPs [45,79], the novelty of this work aims to provide a better understanding of MPs contamination and sources in field-side composts, specifically their concentrations and chemical natures. For that purpose, four field-side composts (named A, B, C, and D) managed by farmers were sampled and treated with MPs’ visual sorting or density separation. MPs were then characterized through ATR and FT-IR analysis.

2. Materials and Methods

2.1. Materials

Before field sampling, the material was washed with hot water and then with milli-Q (ultrapure) water (millipore filtration, Res > 18.2 MΩ·m). All containers were made of glass, TEFLOWN (polytetrafluoroethylene—PTFE), cardboard, or paper. The tools were mainly metallic (hand shovel, ruler), except gloves (nitrile). The material used in the laboratory consisted mostly of metallic containers and tools (trays, tweezers, spatulas, etc.), nitrile gloves, and metallic sieves (ATECHNIK, GmbH, Leinburg, Germany) of various sizes. The ultrapure water (UPW) was obtained with a Milli-Q unit, and supplementary filtration was operated with a cellulose filter of 0.45 µm, Ø47 mm (Whatman International Ltd., Buckinghamshire, UK), into a filtration unit made of glass to reduce MPs’ contamination from UPW. The rest of the tools (beakers, pipettes, Petri dishes) were mainly made of glass or PTFE.

2.2. Methods

The sampling method used was bulk sampling. All the farming exploitations received plant materials, but the origin varied. Four different composts were considered. Compost A was formed from cultures’ wastes, which gave it a brown dirt aspect; Compost B received communal green wastes but no organic household wastes, which provided it a woody aspect with light material; Compost C received wastes from restaurants and vegetal waste disposals and was composed of dark fine material; and Compost D received industrial non-mature compost from green wastes, making the aspect coarse with heavy material. The treatments operated on the composts were also different. For example, Compost C was the only one artificially watered, while Compost B was the only one ground. The mixing was mostly performed at the same rate, except for Compost A’s sample which may have been less mixed or aerated. Regarding the use, all the composts were intended for agricultural purposes, except for Compost C where private users could collect the compost. The composts were sampled mostly on the 9 April and the 30 July 2020.

The compost was collected at a depth of 20–30 cm with a hand shovel and put into glass beakers. For each field-side compost, 5 L of compost was sampled with several punctures, the number of punctures and volume per puncture were adapted to the sample volume, and at least 1 m between each puncture was guaranteed. The farmers were also interviewed on the origin of wastes, treatments, and other information relevant to their compost. Other information, like the temperature, was noted with the help of a glass non-mercury thermometer. The exploitation from Compost C processed organic wastes originating from restaurants, and it was noticed by the receptionist that the wastes often arrived with the remains of packaging or other plastic tags on it. Concerning Composts A and D, illegal dumping was said to be significant in these.
The samples were first frozen to prevent them from degradation. After unfreezing, the samples were mixed by hand separately, weighed, and put in an oven (UF750TS Memmert GmbH + Co. KG, Büchenbach, Germany) to dry at 40–60 °C until it reached a constant weight.

Then, 100 g of each sample was put on a sieving tower with the following sieves: >5 mm; 5–2 mm; 2–1.25 mm; 1.25–0.5 mm, using UPW to transport the compost particles through the sieves. Once the water escaping at the bottom of the tower was clear, the sample was considered fractioned. Duplicates of 100 g compost were made, except for one compost (D) which only had 50 g of material sieved for each duplicate. The different fractions were then dried at 60 °C until constant weight and treated in two ways according to their size range. Fractions > 5 mm, 5–2 mm, and 2–1.25 mm were sorted by hand. The 1.25–0.5 mm fraction was treated with digestion of organic matter and separation density.

The biggest fractions were sorted by visual determination with metal tweezers, a lamp, and a magnifying glass. The particles identified were kept into Petri dishes, in plastic for the biggest fractions (>5 mm, 5–2 mm, no risk of contamination), and in glass for the smaller particles (2–1.25 mm; 1.25–0.5 mm) to avoid contamination (Figure 1).

The organic matter in the smallest fraction was digested with H₂O₂ (30% wt, REACTORLAB, SA, Servion, Switzerland) into a large beaker, which was put in the oven between 40 and 60 °C. The organic matter was considered digested only when there was no sign of remaining reaction (no sizzling or bubbles visible). After this, samples were sieved once again on a 63 µm sieve, washed with UPW, and dried at 60 °C. Then, the fractions were put into large beakers with ~200 mL of NaI (99+% pure anhydrous, Thermoscientific, Mumbai, India) solution of 1.71 g/mL and left a minimum of 17 h. A pipette bulb and a volumetric pipette in glass were used to aspirate the floating MPs. These were deposited on a 63 µm sieve, washed with milli-Q water, and filtered on an Anodisc 47, Whatman®, Buckinghamshire, UK) into a glass filtration unit. The Al₂O₃ filter was then put into a glass Petri dish and dried in the oven at 60 °C.

Particles of >5 mm, 5–2 mm, and 2–1.25 mm were analyzed by ATR directly (ATR analyzer (Spectrum two, UATR Two, Perkin Elmer, Beaconsfield Buckinghamshire, UK) with the associated software Perkin Elmer IR Spectrum V.10.6.2 (PerkinElmer FT-IR, Beaconsfield Buckinghamshire, UK), while particles in the size range 1.25–0.5 mm have been analyzed with an FT-IR spectrometer (FT-IR analyzer (Spotlight 200i, Perkin Elmer, Beaconsfield

![Figure 1. Visual sorting of the plastic particles from 100 g of Compost D for three sieved size fractions.](image-url)
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Buckinghamshire, UK) with associated camera). One-quarter of the Al2O3 filters’ surface was considered for analysis with FT-IR (around 433 mm²). The technical parameters were set as follows: the upper and lower detection limits were 4000 and 1250 nm, the resolution was between 4 and 16, and the number of scans was between 8 and 32. A correspondence score above or equal to 75% with a plastic spectrum from the polyatr library (PerkinElmer, Beaconsfield Buckinghamshire, UK) was chosen to consider the proven plastic particles.

The results of the proven plastic particles were classified into 10 plastic families, by their recurrence: polyethylene (PE), polyethylene methacrylate (PEMA), polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyvinyl alcohol (PVA), polypropylene (PP), nylon, polystyrene (PS), (poly) diallyl iso-phthalate (DAIP), others (for other types of plastics or copolymers that could not be easily classified).

All the results are written as particle numbers per 100 g of compost. The results are means between the duplicates, and standard deviations are mentioned in the graphs. The percentages and mean numbers of proven plastic particles of each polymer family, for each size fraction, and each sample are represented to compare the plastics’ characterization between compost conditions, but also between size ranges.

3. Results
3.1. Concentration of Microplastic Particles

Considering all the composts sampled, the macroplastics (>5 mm) and MPs contamination is estimated between 19.5 ± 6.4 and 131.5 ± 37.5 particles per 100 g of compost. The difference between the number of particles visually sorted and the number of certified plastics through infrared analysis is significant (Figure 2). The concentrations are also estimated according to the fractions’ sizes. The mean between the duplicates was determined, except for the 1.25–0.5 mm fraction which only had one replicate for two composts (Figure 3). The major standard deviation for the Compost C sample is due to one of the duplicates having almost double the quantity of proven MPs, and this is even more true for the 2–1.25 mm fraction. The concentrations according to the size of the fractions sieved show great variations seemingly unrelated to the size parameter.

![Figure 2. Total concentrations of particles analyzed with infrared spectroscopy for each compost (100 g).](image-url)
3.2. Nature of Microplastic Particles

The data in Figure 4 list the plastic family, the mean number of particles belonging to this family, and the percentage (%) of the total macroplastics (>5 mm) or MPs (5–0.5 mm).

For Compost A, analysis of the >5 mm fraction revealed no proven macroplastics. A total of seven plastic categories were found in this compost. Compost B had a lot of woody materials compared to other exploitations. Its concentration in plastic particles was the lowest of all samples, with an average of 19.5 ± 6.4 plastic particles per 100 g of compost. However, for the smallest fraction (1.25–0.5 mm), contrary to what was observed for the total concentration, one can see that Compost B has a high number of plastic particles, mostly PEMA, unseen in other composts (Figure 4). In total, nine plastic categories have been found. Some plastics were only present in one of the duplicates, highlighting the fact that Compost B has a great variety of plastic families with a small quantity of particles in the biggest sizes, as has been seen previously (Figure 2).

Compost C provided the most substantial plastic particle concentration of all, with an average concentration of 131.5 ± 37.5 particles per 100 g of compost. A total of nine plastic families are present in this compost. The number of particles and variety of plastic families can be explained by the origin of wastes, sometimes still wrapped in plastic, making them difficult to sort. It should be noted that Compost D had a lot of macroplastics on its surface, which were not found in the duplicates due to their size which exceeded the sampling tools (Figure 5).

Nonetheless, Compost D has the second-greatest concentration of plastic particles, with around 72 particles per 100 g of compost. A total of six plastic categories are found in this sample. PBT, PVA, and DAIP are not present in the >5 mm fraction but have probably been fragmented into MPs size.

Globally, the major plastic families present are PE, PP, PVA, and DAIP.
Figure 4. Mean number and proportion of proven plastic particles per 100 g of Compost (A–D). The results are separated between macroplastics (>5 mm) and microplastics (between 5 and 0.5 mm).
Figure 5. (a) Macroplastics observable on the surface of Compost D. (b) COVID-19 mask apparently littered on the surface of Compost D. These macroplastics have not been considered in the calculated concentrations due to their size exceeding the size of the sampling tools.

4. Discussion

The results indicate that visual sorting needs further analysis to ensure the nature of the particles (Figure 2) and highlights the omnipresence of plastic particles in all composts. The concentrations in field-side composts are between 195 ± 64 and 1315 ± 375 particles/kg compost. Knowing that these data are underestimated according to the noticeable plastics out of the size range of 5–1.25 mm (see Figures 3 and 5) is concerning. In comparison, Borella [73] estimated a higher concentration of MPs in industrial compost from Geneva, with 44,730 MPs/kg (4473 MPs/100 g). It is difficult, however, to compare directly with other studies, because of several aspects including the methodology and size ranges explored, the type of organic wastes composted, and their treatment (industrial or rural). The industrial composting station taken for comparison here treats around 23,000 t/year of garden and organic household wastes [80,81]. Therefore, the quantities of wastes treated and the fractions analyzed are greater in Borella’s study, which must be considered when comparing them to the results of the present work.

Porterfield et al. [82] compiled several results in a table, which has been modified here to add the present results and Borella’s. One can notice that our study presents fewer plastic particle concentrations, in comparison with similar rural compost (Table 1). However, exploring particle sizes below 1.25 mm could increase the number of particles counted, as seems to be the case regarding Gui et al. [83].

Table 1. Modified table from Porterfield et al. [82]: “Plastic abundance in composts, digestates, and food wastes on a count basis.”.

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Abundance (Particles kg⁻¹ Dry)</th>
<th>Size (mm)</th>
<th>Polymer Types</th>
<th>Location</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td></td>
<td>&gt;0.3 b</td>
<td>n/a</td>
<td>Germany</td>
<td>[84]</td>
</tr>
<tr>
<td>Green waste</td>
<td>12 ± 8 to 46 ± 8</td>
<td>1–5</td>
<td>PLA</td>
<td>The Netherlands</td>
<td>[85]</td>
</tr>
<tr>
<td>Green waste</td>
<td>82,800 ± 17,400 a</td>
<td>0.03–2</td>
<td>PE, PP</td>
<td>The Netherlands</td>
<td>[86]</td>
</tr>
<tr>
<td>Green waste</td>
<td>1253 ± 561</td>
<td>0.05–5</td>
<td>Mostly PP, also PE, nitrile rubber, PES</td>
<td>Lithuania</td>
<td>[87]</td>
</tr>
<tr>
<td>Green waste</td>
<td>5733 ± 850 to 6433 ± 751</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It should be noted that the origin of wastes in this study and in Table 1 seems to influence the concentration of MPs, as accepting organic household wastes might increase the MPs contamination if the population is not sensitized enough about this problem. Then, with the characterization of the MPs’ chemical nature, the evolution of plastic types with size does not show a clear trend, suggesting that there is no link between a plastic family and its distribution according to size range, but still puts forward that MPs are more numerous than macroplastics >5 mm. Also, the fact that the substrate is different among the exploitations did not seem to influence the variability or the proportions of plastics, except for the rural Compost B which has a specific presence of PEMA unseen in other composts. This type of polymer has different properties such as shape memory, water vapor barrier, or toughening agent, which allows it to have various purposes like packaging, photovoltaic applications, or armor and self-healing materials [92]. Since this kind of plastic is less common, it would be interesting to investigate the location of the compost and the close potential sources of PEMA.

The use of a screening machine does not seem to have a significant impact on the composition of the sample’s MPs. However, the potentiality that processing wastes only originating from exploitation can lower the variability of plastic types, as in Compost A, can be put forward.

Globally, there does not seem to be a tendency for degradation abilities according to the different plastic families. However, it can be noticed that PE, PVA, PP, DAIP, and PEMA have increasing concentrations with diminution of the fractions’ sizes or the significant presence with a high number of particles. This can indicate that those plastic types do not (or hardly) degrade, making them potential particularly persistent plastics.

In this sense, no clear demarking or specific similarity could be found between the different composts, despite their variations in organic wastes’ origins, material compositions, degrading conditions, and treatments. Yet, one can observe that non-degradable MPs from at least six different plastic families can be found in significant concentrations in all composts. PE can often be found in packaging materials for food or drinks, PP is commonly

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**Table 1.** Cont.

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Abundance (Particles kg⁻¹ Dry)</th>
<th>Size (mm)</th>
<th>Polymer Types</th>
<th>Location</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green and household waste</td>
<td>20–24</td>
<td>&gt;1</td>
<td>Mostly styrene-based polymers (PS etc.) and PE, also PES, PP, PET, PVC</td>
<td>Germany</td>
<td>[88]</td>
</tr>
<tr>
<td>Food waste</td>
<td>3783 ± 351 to 4066 ± 658</td>
<td>0.05–5</td>
<td>Mostly PE and PS, also PET, PP</td>
<td>Lithuania</td>
<td>[87]</td>
</tr>
<tr>
<td>Household biowaste</td>
<td>32 ± 20 b</td>
<td>&gt;0.3 b</td>
<td>n/a</td>
<td>Germany</td>
<td>[84]</td>
</tr>
<tr>
<td>Rural domestic waste</td>
<td>2400 ± 358</td>
<td>0.05–5</td>
<td>Mostly PES, PE and PE, also PVC, PS, PE, PP, PU</td>
<td>China</td>
<td>[83]</td>
</tr>
<tr>
<td>Rural, domestic, and green waste</td>
<td>195 ± 64 to 1315 ± 375</td>
<td>&gt;1.25–&gt;5</td>
<td>PE, PP, PET, PBT, PS, PVA, DAIP, PEMA, Nylon, Other</td>
<td>Switzerland</td>
<td>Present work</td>
</tr>
<tr>
<td>OFMW digestate</td>
<td>44,730</td>
<td>&gt;0.063–&gt;5</td>
<td>Mostly PE, PP, PS, and PVC</td>
<td>Switzerland</td>
<td>[73]</td>
</tr>
<tr>
<td>OFMW digestate</td>
<td>39–102</td>
<td>1–5</td>
<td>Mostly PE and PVC, also PET, PS, PES, PUR, and other</td>
<td>Germany</td>
<td>[89]</td>
</tr>
<tr>
<td>OFMW</td>
<td>2800 ± 616</td>
<td>0.03–2</td>
<td>PE, PP</td>
<td>The Netherlands</td>
<td>[86]</td>
</tr>
<tr>
<td>OFMW</td>
<td>10,000–30,000</td>
<td>&gt;0.025</td>
<td>Mostly PE, also PS, PP, PES, PVC, and ACR</td>
<td>Spain</td>
<td>[90]</td>
</tr>
<tr>
<td>Unknown</td>
<td>5.2–42.8 (15.4) Mila</td>
<td>0.005–1</td>
<td>n/a</td>
<td>Austria</td>
<td>[91]</td>
</tr>
</tbody>
</table>

Abbreviations: OFMW, organic fraction municipal waste; ACR, acrylic polymers; CE, cellophane; PA, polyamide; EVA, ethylene vinyl acetate; PE, polyethylene; PES, polyester; PET, polyethylene terephthalate; PLA, polylactic acid; PP, polypropylene; PS, polystyrene; PU/PUR, polyurethane; PVC, polyvinyl chloride; PVDC, polyvinylidene chloride. a Dry/as-is not reconciled. b Estimated from figure.
used in textiles, and DAIP is usually used for its heat resistance and electrical properties in molding materials and electronic connectors [93,94]. They are all water resistant, unlike PVA, commonly used as a coating or thickening agent in glues, paint, or medicines [95].

The recommendations to avoid the presence of plastics in composts are to increase the sorting with the use of plastic vacuums and to mostly avoid processing organic wastes containing plastics [62]. But these recommendations can hardly be implemented in the present situation. In addition, untreated wastes would remain and should be treated instead of relying on their disposal in landfills. This implies that actions are required to monitor and evaluate the possibilities to help to reduce or avoid plastic contamination in field-side composting.

5. Conclusions

Despite the efforts to sort and avoid plastic contamination or having different conditions and treatments, the results revealed that all sampled field-side composts contained conventional plastic particles. This study highlighted the omnipresence of plastic particles, but also the variety of chemical nature and concentrations in field-side composts.

However, differences among composts, possibly induced by the origin of wastes, have been noticed. The compost with the highest concentration of plastic particles had $1315 \pm 375$ particles/kg compost ($131.5 \pm 37.5$ particles/100 g), potentially because the organic wastes were still wrapped in plastic films or had tags on it once arriving at the exploitation, rendering the sorting difficult. This was not the case for one of the composts free from organic household wastes, which had the lowest concentration estimated at $195 \pm 46$ particles/kg ($19.5 \pm 6.4$ particles/100 g). Another hypothesis explaining why differences were noticed is illegal littering, as this type of problem is encountered by some farmers. But further analysis is required to confirm those hypotheses, as MPs can be transported by many means.

Concerning the concentrations of MPs according to the sieving size or fraction, the mean number of particles does not seem to follow a tendency according to the size of studied fractions, unlike other studies on MPs in composts. Including smaller size fractions could, however, change this tendency, as it appears in these studies that MPs’ concentrations rise with a diminution of observed sizes.

Regarding the nature of MPs, the results showed that several conventional plastic families have been found in field-side composts. No clear tendency can be drawn at this point concerning the link between the presence of certain plastic families and the composts or the origin of wastes. However, there are a few possible avenues to explore, as controlling the origin of wastes can supposedly reduce the variety of plastic families or change the presence of certain plastic types. The close environment can possibly explain the presence of specific plastic types, as seen for PEMA. Also, regarding the degradation abilities of plastics, the fact that PE, PVA, PP, DAIP, and PEMA have been found in the smallest fractions might indicate that these plastics are particularly persistent and will fragment into smaller MPs, increasing the concentration of particles/kg of compost.

Yet, to increase the precision of the results, consistent monitoring should be elaborated with an adapted methodology to help to sort MPs from organic matter. This could also allow the evaluation of the usual concentrations through seasonal variations and help to set an acceptable limit in composts. Further insights are needed to understand fluctuations according to the composts’ conditions like temperature, humidity, treatments, and especially the origin of wastes. In the same way, the influence of other external contamination pathways, like littering, should also be closely observed to assess their relevance toward the MPs concentrations in composts.

Therefore, it is no wonder that biodegradability in composting conditions becomes a motivation to produce bioplastics or more likely compostable plastics. Yet, even compostable plastics can be found in the compost if they cannot fully degrade, in addition to potentially containing non-biodegradable plastics within them. This would imply
that even some materials labeled as compostable are not fully degradable in field-side composting conditions.

This study showed that MPs contamination is a multifactorial problem that needs to be addressed through various insights, be it quantitatively, by the chemical composition of plastics, but also through the socio-economical perspectives, as farmers noticed concerning behaviors regarding the sorting or littering of plastics. The nature of plastics offered a point of view of the different economical industries as to which products can end up in the compost material.

**Supplementary Materials:** The following supporting information can be downloaded at: [https://www.mdpi.com/article/10.3390/microplastics3030030/s1](https://www.mdpi.com/article/10.3390/microplastics3030030/s1).


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