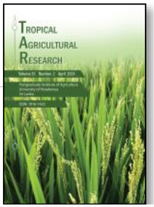
Tropical Agricultural Research (2024) 35(2):119-130

Contents available at: Sri Lanka Journals Online

Tropical Agricultural Research

Journal Home Page: https://tar.sljol.info



RESEARCH

Microplastic Abundance in the Locally Produced Commercial Compost and the Characteristics

A.S.Y.P. Ranasingha[1,2]*, A.K. Karunarathna[2], W.S. Dandeniya[2], M.S. Nijamudeen[1] and G.N. Hewagama[3]

[1]Sustainable Agriculture Research and Development Centre, Makandura, Gonawila, Sri Lanka
[2]Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka
[3]Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka

ARTICLE INFO

Article history:
Received: 15 August 2023
Revised version received: 05 March 2024
Accepted: 21 March 2024
Available online: 01 April 2024

Keywords:
Agricultural waste
Contaminant
Organic fertilizer
Municipal solid waste

Citation:
Ranasingha, A.S.Y.P., Karunarathna, A.K., Dandeniya, W.S., Nijamudeen, M.S. and Hewagama, G.N. (2024). Microplastic Abundance in the Locally Produced Commercial Compost and the Characteristics. Tropical Agricultural Research, 35(2): 119-130.

DOI:
https://doi.org/10.4038/tar.v35i2.8743

Ranasingha, A.S.Y.P.
https://orcid.org/0009-0009-9530-4149

ABSTRACT

Compost is a widely used soil amendment in the agricultural sector in Sri Lanka. Applying compost could improve soil quality, and it is used in reclaiming degraded agricultural lands. However, low grade compost that contains pollutants may have adverse effects on the quality of the agro-ecosystem. Microplastic is a possible contaminant that can be moved into the agro-ecosystem through poor quality compost application. The present study was conducted to assess the microplastic availability and characteristics of locally produced municipal solid waste and agricultural waste compost. Representing commercial scale agricultural and municipal solid waste composting facilities; twenty compost samples with three replicates were obtained for microplastic identification. A combination of methods (manual separation, oxidation digestion plus density separation) was used to separate and detect microplastics from compost samples. This study revealed that; microplastics are present in agricultural and municipal solid waste compost. Municipal solid waste compost contained significantly ($p<0.05$) higher microplastic than agricultural waste compost (on average 0.63% and 0.033%, respectively). Average amount of soft plastic content in municipal solid waste compost and agricultural waste compost (1321 items/kg and 71 items/kg, respectively) were higher than the hard plastics (388 items/kg and 37 items/kg, respectively). The study confirmed that compost could act as a carrier of microplastics in agricultural ecosystems. It can be recommended that quality standards should be implemented to minimize the microplastic content in compost and the code of practices for municipal solid waste compost production should be updated to control microplastic contamination to safeguard the quality of agro-ecosystems.

---

*Corresponding author- yasarapradeep@gmail.com

INTRODUCTION

Applying organic amendments is a valuable strategy in integrated plant nutrient management system. This practice helps to overcome limitations of entirely depending on inorganic fertilizers for crop nutrient management. Because it helps to maintain and improve soil carbon content and stabilize and improve soil fertility (Scotti et al., 2015). In the late 1990s, the Department of Agriculture (DOA), Sri Lanka encouraged farmers to apply organic manure and introduced an integrated plant nutrient system (IPNS). Present fertilizer recommendations of DOA have been developed based on the IPNS strategy (Dandeniya & Caucci, 2020; Nadeesha et al., 2022).

In Sri Lanka, compost is widely produced and used as organic soil amendment/fertilizer, which accounts for about 92% of the total organic fertilizer industry (Nadeesha et al., 2022). Sri Lanka Standard Institute (SLSI) has published quality standards for compost originating from municipal solid waste and agricultural waste (SLS 1635:2019 and SLS 1634:2019). In the standards, compost is defined as “Relatively stable decomposed / processed product resulting from decomposition with similar characteristics as humus, made from biodegradable constituents, which contain considerable amounts of plant nutrients” (SLS 1635:2019). There are two types of commercial-scale compost in Sri Lanka; namely agricultural waste compost (AgWC) and municipal solid waste compost (MSWC). Byproducts from the agriculture sector (agricultural residues) and plant-based materials are used to produce AgWC, while biodegradable municipal solid waste is used to produce MSWC (SLS 1635:2019 and SLS 1634:2019). The producers of AgWC can be categorized into three groups considering the annual production capacity (Nadeesha et al., 2022). They are; Large-scale (LS) producers (>300 MT/Year), Medium-scale (MS) producers (60-300 MT/Year), and Small-scale (SS) producers (<60 MT/Year). With the scale of producers; production facility condition, raw material usage, composting process management, and final processing activities are different between each group (Ranasingha et al., 2023). Considering the management authority, MSWC facilities can be categorized into three groups including Municipal Councils (MC), Urban Councils (UC), and *Pradesheeya Sabhas* (PS). Among these groups of MSWC facilities, the raw material collection and separation, production facility condition, composting process management, and final processing activities are different (Samarasingha et al., 2015). Qualities of the final compost produced by different groups vary with the composition of feedstock materials, composting process management, and final processing (Samarasingha et al., 2015; Nadeesha et al., 2022). The final target of both AgWC and MSWC composters are to market their product for agricultural purpose (Samarasingha et al., 2015; Nadeesha et al., 2022).

Even though there are many beneficial effects of compost application, some negative issues may arise when using low quality compost. The main issues are adverse pH and Electrical Conductivity (EC) values, soil contamination by pollutants such as potentially toxic elements (PTEs) and persistent organic pollutants (POPs), impurities like iron particles, microplastics, glass particles, etc., and biological contaminants (Brandli et al., 2005; Farrell et al., 2009). Microplastics in compost are considered as pollutants of emerging concern related to the soil environment (Dandeniya and Caucci, 2020). This is because microplastics have more significant environmental risks to soil quality and ecosystems; plastic fragments can have various impacts, such as changes in soil functions and influences the soil physical, chemical, and biological properties. (Machado et al., 2018; Baile Xu et al., 2020). Frias and Nash, (2018) defined microplastic as “any synthetic solid particle or polymeric matrix, with regular or irregular shape and size ranging from 1 μm to 5 mm, of either primary or secondary manufacturing origin, which is insoluble in water”. Smith (2018) reported that micro and nano plastic can bio-accumulate in plant tissues, increasing the risks to human health. Another hazard of microplastics is that it contains plenty of POPs and PTEs; they absorb organic and inorganic pollutants, possibly affecting the distribution of these pollutants in soil and can move in agro-ecosystem (Baile Xu et al., 2020; Vithanage et al., 2021). During the production process, toxic metals are mixed with plastics, and these metals can remain with microplastics. On the other hand, the surface of the microplastics can be harbor to toxic metals (Vithanage et al., 2021).

Compost and plastic mulches are significant sources of plastic contamination in agricultural systems (Schothorst et al., 2021). Many research findings proved that compost is a key source of microplastics in agricultural fields and compost could contribute an average of 10 to 2800 items of microplastics/kg compost (Vithanage et al., 2021). Another study reported that microplastics were significantly higher in compost-applied soil than those that did not receive compost (Zhang et al., 2022). Also, secondary microplastics are produced during the composting process; mechanical shearing and tearing forces, temperature, chemical oxidation, and biodegradation lead to the breakdown of macroplastics of raw materials into minor pieces. Thus, at the late stage of the composting process the amount of small-sized microplastics is increasing (Gui, 2021). With the risk of microplastic inputs through compost application to agricultural land, it is recommended to evaluate the effect of microplastics on soil functions and develop standards for regulating compost quality related to microplastics (Colombini et al., 2022). For informed decision-making to regulate the total inflow of plastic pollution to agricultural soils, it is important to have a thorough understanding of microplastic contamination levels in compost, their characteristics, and vector transport behavior (Vithanage et al., 2021). In Sri Lanka, information on microplastic occurrence and characteristics in locally produced compost is limited. According to SLS 1635:2019 and SLS 1634:2019, any visible foreign materials such as metal, stones, plastic, textile, polythene pieces, etc. should not be present in compost. However, these standards do not specifically mention the microplastic contamination in compost. Therefore, assessing microplastic contamination in compost is essential to formulate regulations to ensure the quality of compost and protect the health of agro-ecosystems. This research was conducted to determine the availability and the characteristics of microplastics in compost producer categories representing AgWC and MSWC commercial-scale in Sri Lanka.

METHODOLOGY

Collection of compost samples from sites

In this study, 20 compost producers were selected representing commercial scale AgWC (8 facilities) and MSWC producer (12 facilities) categories from different areas of the country. Representing MSWC facilities four from each municipal council (MC), urban council (UC), and *Pradheshiya sabha* (PS) categories were included in the study. Representing AgWC facilities three from each large scale (LS) and medium scale (MS), with two from small scale (SS) categories were included. Ten kilograms of representative compost samples were collected from finalized marketable pack from each compost production site according to the guideline provided by SLSI for compost sampling (SLS 1635:2019 and SLS 1634:2019). From each of the above-mentioned compost sample, 100 g of sub-samples with three replicates were obtained for further microplastic identification. Accordingly, the total number of samples used in the study was sixty. Samples were brought to the soil science laboratory of the Sustainable Agriculture Research and Development Center (SARDC), Makandura and processed. The analyses were performed at SARDC and in the soil science laboratory at the Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, from November 2021 to May 2022.

Separation and detection of microplastics from compost

Separation of microplastic from compost by the existing technology is difficult because compost contains high amount of organic matter and removing that organic matter content from compost is extremely hard. The most microplastic detecting methods have been developed for marine environments, sediment, and sludge (Radford *et al.* 2021). The above methods included visual microscopic identification, heat treatment, oxidate digestion, and density separation. The combining of analytical methods (Figure 1) helps to identify microplastics in diverse and complex environmental matrices such as soil and compost. Thus, in this study, a combination of methods was used to separate and detect microplastics from compost samples (Figure 1).

Sample pre-preparation

Compost samples were dried at room temperature until they reached a constant weight. After air-drying, the compost samples were gently grounded by hand with slight force to break down clods. Then, by using 5 mm stainless steel mesh, the compost sample was sieved. Magnetic materials were removed by using a magnet, and the remaining samples were used for further analysis.

Manual separation

The compost sample passed through 5 mm sieve and 10 g was obtained. This sample sieved through a stainless-steel sieve set with sieve sizes of 4 mm, 2 mm, 1 mm, and 0.5 mm. After sieving through the four sieves, the sample retained on each sieve was taken for micro-plastic analysis. Microplastics were manually separated from compost retained in each sieve. This is easy, simple, and fast method for identifying 0.5 – 5mm size range microplastics (Shim et al., 2017). Then the compost retained in each sieve was spread on petri dishes separately into a thin layer, and visible microplastic particles were manually picked up carefully by using forceps while observing through a magnifying lens (3X) (Figure 2 and Figure 3). Separated microplastic particles from each sample (Figure 5) were counted (C_1) and weighted (W_1).

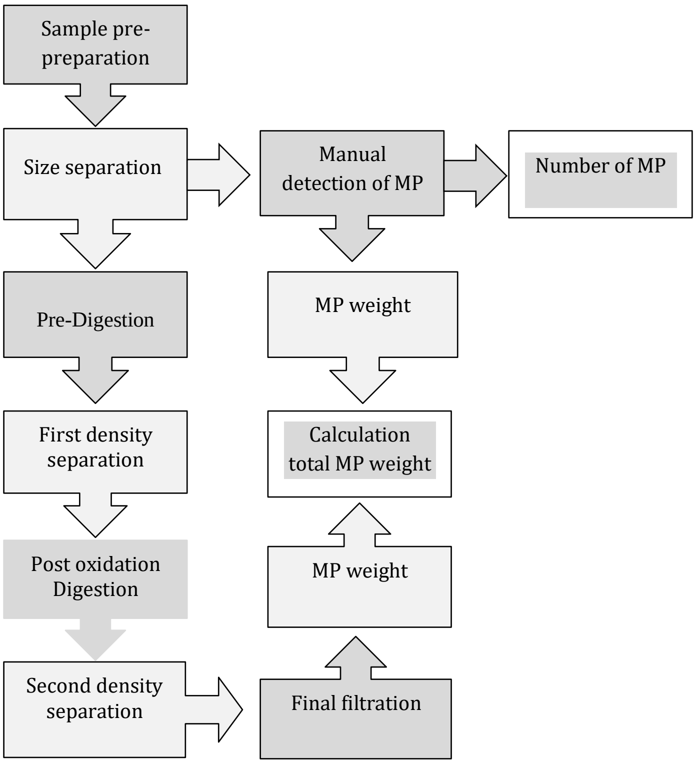


Figure 1: Combined methods adopted for microplastic detection of compost
(Produced using the information from Shim et al., 2017; Hurley et al., 2018; Federica et al., 2020; Lavoy and Crossman 2021; Mercedes and Jill 2021; Radford *et al* 2021)

Figure 2: Manual separation of microplastic (A- Sieve set, B-Magnetic separation, C-Manual pick up of microplastic, D-0.5mm to 5mm size separated microplastic)

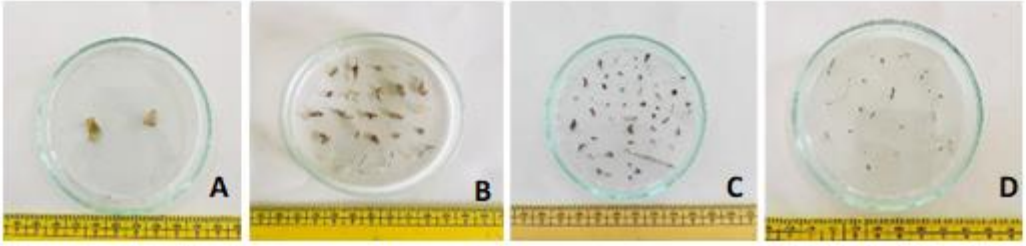


Figure 3: Separated microplastic in different size (A: 4-5 mm, B: 2-4mm, C: 1-2mm, D: 0.5-1mm)

Density separation

After manual separation of visible microplastics, the remaining compost samples were added to the 250 ml beaker. Then 25 ml 30% hydrogen peroxide solution (H_2O_2), and 10 ml of a 0.05 M iron catalyst ($FeSO_4$) (Fenton's reagent) were added slowly. After that, the beaker was heated up to 70 ˚C in a water bath while frequently stirring until the sample got nearly dry and then kept until cooling down for the downstream analyses. After that, 200 ml of 25% NaCl (w/v in water) was added to the beaker and stirred for 2 minutes by using a magnetic stirrer. Then the sample was allowed to stand until overlaying solution look clear (About 12 hours). To minimize the contamination from airborne particulates, samples, and equipment were covered with aluminum foil papers. Then using 50 ml pipette the supernatant was transferred into another 250 ml beaker and heated up to 70 ˚C in a water bath until the sample become nearly dry. Then 10 ml of 30% hydrogen peroxide solution and 3 ml of a 0.05 M iron catalyst ($FeSO_4$) were added to the beaker and kept in a water bath at 70 ˚C until the reaction ceased. Then again, 200 ml of 25% NaCl (w/v in water) was added to the beaker and stirred it 2 minutes by using a magnetic stirrer. Then the sample was kept stationed covered with aluminum foil papers until overlaying solution look clear (About 12 hours).

As the next step, Whatman No. 42 filter papers were dried at 50 ˚C in an oven until getting constant weight (W_2). Using 50 ml pipette, all supernatant was siphoned out and transferred to the pre-weighed filter paper. Pipette was rinsed with distilled water and put onto the filter paper. By using distilled water, remain NaCl solution on the filter paper was washed through itself to ensure no remaining NaCl solution was on the filter paper before drying. After filtration, filter paper was placed in the petri dish and covered using aluminum foil. Then petri dish with filter paper was placed in an oven and dried at 50 ˚C to until the filter paper got constant weight. After that, the weight of the filter paper with the microplastics was recorded (W_3).

Calculation

Total number of microplastics in 1kg compost
$= (C_1/10) \times 1000$
Microplastic weight after digestion
$= (W_3-W_2) = W_4$
Microplastic weight in 1kg compost
$= ((W_1+W_4)/10) \times 1000$

Statistical analysis

An independent-samples t-test was used to examine the mean difference in the amount and weight of microplastic in MSWC and AgWC at a 95% confidence level. One-way analysis of variance (ANOVA) was used to determine the significant effect of the compost producers and composting technology groups on MP abundance. In the case of being significant in ANOVA, the least significant difference (LSD) was selected as the posthoc analysis to assess significant differences of diverse groups at p = 0.05 probability level.

RESULTS AND DISCUSSION

Amount of microplastic by manual separation

The results of the manual separation revealed that microplastic particles were present in all the MSWC and 25% of the AgWC samples studied. The average microplastic counts in major producer categories are shown in Figure 4.

The number of microplastics in compost samples collected from different locations ranged from 430 to 4566 items/kg. All categories of MSWC samples had significantly higher microplastic than AgWC (Table 1). Previous research reported that microplastic amounts ranged from 7172 to 17188 items/kg in MSWC (Zhang et al., 2022). Jiaxi Gui (2021) showed that in the compost produced from domestic waste microplastic content could range from 2152 to 2990 items/kg.

Analysis of microplastic size showed that most of the particles collected from various compost samples were between 2 and 5 mm. However, Gui (2021) reported that the main microplastic component in domestic waste compost with a particle size <1 mm. Plastics in municipal solid waste are categorized as soft (polyethylene bags, lunch sheets, polyethylene sheets, etc.) and hard plastics (PVC pipe, water bottles, plastic cans, etc.) (JICA, 2016). The observed compost samples had more soft plastics than hard plastics (Figure 5). These results comply with early research findings that indicate there are clear differences in hard vs. soft microplastic particles among compost from municipal solid waste and agricultural waste (Madushani et al., 2020; Hewagama et al., 2022).

The reason for higher soft microplastic with compost is soft plastics contain more than hard plastics in municipal solid waste. It is reported that municipal solid waste contains an average of 6% soft plastics and 1% hard plastics (JICA, 2016). Other reasons for high contamination by soft microplastic is that soft plastic separation from the biodegradable waste is difficult at the point of origin and the production facilities, and also during the composting process soft plastic easily breakdown and produces more microplastic (Gui, 2021).

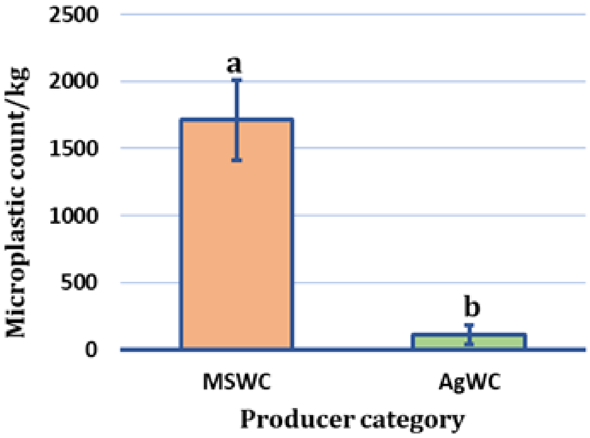


Figure 4: Comparison of MSWC and AgWC microplastic count. Error bar are represented standard error of mean. Lower case letters are indicated significant differences between sample groups ($p<0.05$). (MSWC–Municipal solid waste compost, AgWC–Agricultural waste compost)

Table 1: Average microplastic count in different producer categories

Producer category	Average MP count/Kg
MSWC-MC	2567± 699^a
MSWC-UC	1197±217^a
MSWC-PS	1365±236^a
AgWC-LS	143±143^b
AgWC-MS	0^b
AgWC-SS	217±217^b

± standard error of mean.
Lower case letters are indicated significant differences between sample groups ($p<0.05$).
(MP - Microplastic, MSWC – Municipal Solid Waste Compost, AgWC–Agricultural Waste Compost, MC–Municipal Council,
UC–Urban Council, PS – *Phradeshiya Sabha*, LS-Large Scale, MS-Medium Scale, SS-Small Scale)

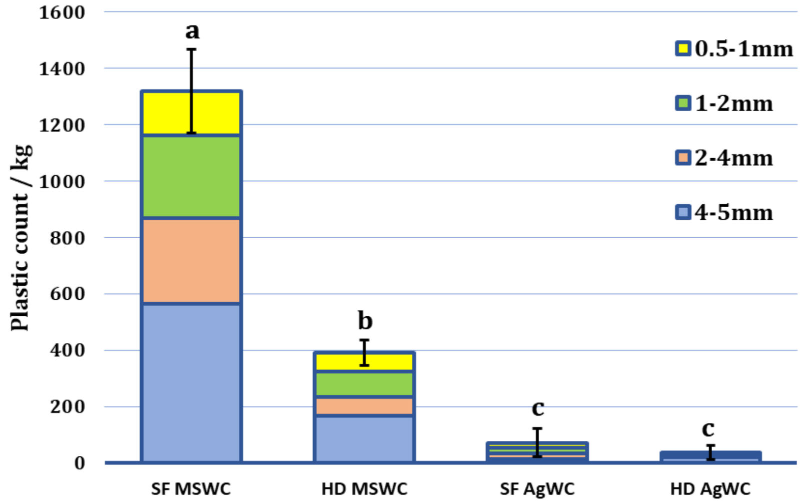


Figure 5: Different sized soft and hard microplastic counts per kilogram of MSWC and AgWC

Error bar are represented standard error of mean.
Lower case letters are indicated significant differences between sample groups ($p<0.05$).
(MSWC – Municipal solid waste compost, AgWC – Agricultural waste compost, SF – Soft microplastic, HD - Hard microplastic)

Mass of microplastic

The results of the density separation revealed that microplastics were present in all the compost samples studied. The quantities showed relatively a wide range; from 0.007 g/kg to 11.196 g/kg. All categories of MSWC samples had significantly higher ($p<0.05$) microplastic mass than AgWC categories (Table 2 and Table 3).

Table 3 presents the microplastic percentages observed in compost in this study. On average, microplastic content in MSWC exceeded the acceptable level of microplastic reported in European countries' compost regulation guidelines. About 25% of the MSWC samples met the acceptable level of EU and United Kingdom regulation, and all analyzed MSWC samples exceeded the Switzerland microplastic limit for commercial compost. All AgWC samples were below the EU, United Kingdom, and Switzerland microplastic limit.

Table 2: Average microplastic mass in different producer categories

Producer category	Average MP* g/Kg
MSWC-MC	7.602±1.492^c
MSWC-UC	4.390±1.025^c
MSWC-PS	6.938±0.614^c
AgWC-LS	0.293±0.285^d
AgWC-MS	0.155±0.015^d
AgWC-SS	0.635±0.625^d

± standard error of mean.
Lower case letters are indicated significant differences between sample groups ($p<0.05$).
* Mass of microplastic on dry weight basis
(MP - Microplastic, MSWC – Municipal Solid Waste Compost, AgWC–Agricultural Waste Compost, MC–Municipal Council,
UC–Urban Council, PS – *Phradeshiya Sabha*, LS-Large Scale, MS-Medium Scale, SS-Small Scale).

Table 3: Microplastic percentage of compost compared with standards of other countries

Producer Category	Mean MP %^{1}	Eropean Union*	United Kingdom*	Switzerland *
MSWC	0.631±0.071	≤ 0.5%^{1}	< 0.5%^{1}	0.1%^{1}
AgWC	0.033±0.017			

*Source - Brinton, 2000. ECN-QAS, 2014
± - standard error of mean, 1- percent values are given as mass on dry basis
MSWC- Municipal solid waste compost, AgWC – Agricultural waste compost, MP – Microplastic

Results of the present study revealed that MSWC samples contained significantly ($p<0.05$) higher microplastic amount and mass than the AgWC samples (Table 1, 2 and 3). Madushani *et al.* (2021) and Hewage *et al.* (2022) also reported that MSWC contains more microplastic than AgWC. Another study reported that MSWC is more contaminated with microplastics than garden waste compost, and the microplastics count in MSWC were 2800±616 items/kg (Schothorst et al., 2021). Raw materials used to produce AgWC have less probability of contamination with plastics. That was the main reason MSWC contained more microplastics than AgWC.

Compost produced by the municipal council contained more microplastics than other local authorities. However, no significant ($p>0.05$) difference were observed between MSWC categories regarding MP count or mass (Table 1 and 2). When considering the LS, MS, and SS of AgWC producers, there was no significant ($p>0.05$) difference in microplastic count and mass in each AgWC group (Table 1 and 2). The study revealed that from composting technologies practiced by local authorities, open windrow composting facilities contained 6.66±1.09 MP g/kg and 1720±579 MP items/kg, while Kawashima composting facilities represented 6.49±0.84 g/kg and 1893±141 MP items/kg. However, there was no significant ($p>0.05$) difference in microplastic count or mass among composting technology practiced by local authorities.

Solid waste generation in the country is around 10768 MT/Day (Ministry of Environment, 2021). It was found that, on average, plastic comprised 6.89% of total municipal solid waste (Ministry of Environment, 2021). Current practice is sorting out biodegradable waste fraction from the solid waste by separating at the origin and further separation at the composting facility. However, in practice, removing all plastics from solid waste is difficult. Due to lack of knowledge and awareness about source separation practices and their benefits, most waste collected in Sri Lanka is not adequately sorted at the collection point (Samarasiri et al., 2021). More than 90% of MSW composting facilities receive mixed waste, which is manually separated in the facility. (Madhushika et al., 2016). As observed on site, more biodegradable MSW used to produce compost are contaminants, often including plastics (Figures 6 and 7).

Separating non-biodegradable waste from biodegradable waste at the place of origin is the only feasible remedy to control compost contamination by impurities, including macro and microplastic (Liyanage *et al.* 2015). A pilot project conducted by selected local authorities of Sri Lanka (2017-2019) proved that, through proper awareness programs and by accepting only the separated waste during the collection, composting facilities may receive 98.3% biodegradable waste with 1.7% non-biodegradable waste. It was reported that during the above project period, 9.4% of plastic contamination in waste was reduced up to 0.1% (Sato et al., 2020).

CONCLUSIONS

The study confirmed that microplastics are present in agricultural and municipal solid waste compost. Municipal solid waste compost contained nearly 20 time higher microplastic than agricultural waste compost. The amount of soft plastic content was higher than the hard plastics. The result revealed that the compost could act as a source of microplastics to agricultural lands. In particular, compost from municipal solid waste should be closely monitored to reduce the loading of microplastics polluting agricultural ecosystems. With this result, it can be recommended that the quality standards should be implemented to minimize the microplastic content in compost, and strategies should be developed to control microplastic contamination of soils to safeguard the quality of agro-ecosystems.

Figure 6: Municipal solid waste contaminated with plastics debris

Figure 7: Plastic separation at the composting facility

ACKNOWLEDGMENTS

The authors wish to acknowledge the National Agriculture Research Plan (NARP) for providing financial assistance, Prof. B. Gajanayaka and all staff members of the soil science laboratory Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, and All staff members of soil science laboratory, Sustainable Agriculture Research and Development Centre-Makandura.

REFERENCES

Baile Xu, Fei Liu, Zachary C., Dan H., Zhijiang Lu, Yan He, Haizhen W., Zhenmei Lu, Philip C. B., Caixian T., Jay Gan & Jianming Xu (2020). Microplastics in the soil environment: Occurrence, risks, interactions, and fate – A review, Environmental Science and Technology. 50:21, 2175-2222, DOI: 10.1080/10643389.2019.1694822

Brandli, R.C., Bucheli, T.D., Kupper, T., Furrer, R., Stadelmann, F.X. & Tarradellas, J. (2005). Persistent Organic Pollutants in Source-Separated Compost and Its Feedstock Materials.—A Review of Field Studies, *Journal of Environmental Quality,* 34(3), 735- 760.

Brinton, W. F. (2000). Compost Quality Standards & Guidelines, Woods End Research Laboratory, 9-12

Colombini, G., Rumpel C., Houot S., Biron P. & Dignac, M. F. (2022). A long-term field experiment confirms the necessity of improving biowaste sorting to decrease coarse microplastic inputs in compost-amended soils. Environmental Pollution. 315, 120369. doi.org/10.1016/j.envpol.2022.120369

Dandeniya, W.S. & Caucci, S. (2020). Composting in Sri Lanka: Policies, Practices, Challenges, and Emerging Concerns. In: Hettiarachchi H., Caucci S., Schwärzel K. (eds) Organic Waste Composting through Nexus Thinking. Springer, Cham. doi.org/10.1007/978-3-030- 36283-6_4

Dandeniya, W.S. & Dharmakeerthi, R.S. (2020). Integrated Plant Nutrient Management in Major Agricultural Soils of Sri Lanka: A Review of the Current Status and the Way Forward. Agricultural Research for Sustainable Food Systems in Sri Lanka. Springer, Singapore. doi.org/10.1007/978-981-15-3673-1_10

European Compost Network, (2014). European Quality Assurance Scheme for Compost and Digestate, (ECN-QAS 2014), - www.ecn-qas.eu (Accessed on 05.07.2023)

Farrell, M. & Jones, D. L. (2009). Critical evaluation of municipal solid waste composting and potential compost markets. Bioresource Technology. doi:10.1016/j.biortech.2009.04.029

Federica, R., Riccardo, G. & Claudio, L. (2020). Methodologies for Microplastics Recovery and Identification in Heterogeneous Solid Matrices: A Review, Journal of Polymers and the Environment, 28(3), 739-748. doi.org/10.1007/s10924-019-01644-3

Frias, J.P.G.L. & Nash, R. (2018). Microplastics: Finding a consensus on the definition, Marine Pollution Bulletin, 138 (2019) 145–147

Gui, J., Sun, Y., Wang, J., Chen, X., Zhang, S. & Wu D. (2021). Microplastics in composting of rural domestic waste: abundance, characteristics, and release from the surface of macroplastics. Environmental Pollution 274, 116553. doi.org/10.1016/j.envpol.2021.116553

Hewagama, G.N., Ranasinghe, P. & Gajanayake, B. (2022). Determination of Availability of Microplastics in Commercial Compost, Proceedings of 20th Agricultural Research Symposium, Wayamba University of Sri Lanka, 295 – 300.

Hurley, R. R., L. Lusher, A. L., Olsen, M. & Nizzett, L. (2018). Validation of a Method for Extracting Microplastics from Complex, Organic-Rich Environmental Matrices. Environ. Sci. Technol. 2018, 52, 7409–7417 DOI: 10.1021/acs.est.8b01517.

JICA, (2016). Data Collection Survey on Solid Waste Management in Democratic Socialist Republic of Sri Lanka, Kokusai Kogyo Co., Ltd.

Lavoy, M. & Crossman, J. A. (2021). A novel method for organic matter removal from samples containing microplastics. Environmental Pollution 286, 117357. doi.org/10.1016/j.envpol.2021.117357

Liyanage, B. C., Gurusinghe, R., Heart, S. & Tateda, M. (2015). Case Study: Finding Better Solutions for Municipal Solid Waste Management in a Semi-Local Authority in Sri Lanka. *Open Journal of Civil Engineering*, 5, 63-73. doi.org/10.4236/ojce.2015.51007

Machado, A. A. D. S., Lau, C. W., Till, J., Kloas, W., Lehmann, A., Becker, R. & Rilling, M. C. (2018). Impacts of Micro-plastics on the Soil Biophysical Environment, Environ. Sci. Technol. 52, 9656–9665. DOI: 10.1021/acs.est.8b02212

Madusanka, K. H. P., Matsuto, T., Tojo, Y. and Hwang I. (2016). Questionnaire & onsite survey on municipal solid waste composting in Sri Lanka, springer publication. DOI 10.1007/s10163-016-0479-y

Madhushani, M. M. K., Karunarathna, A. K., & Ranasingha, A.S.Y.P. (2020). Assessment of Occurrence and Types of Microplastic in commercial compost, Proceeding of the 7th undergraduate research symposium, Faculty of Agriculture, University of Peradeniya, 171

Mercedes, L. & Jill, C. (2021). A novel method for organic matter removal from samples containing microplastics. *Environmental Pollution*, 286, 117-357.

Ministry of Environment, Sri Lanka. (2021). National Action Plan on Plastic Waste Management 2021-2030. Sobadham Piyasa, Battaramulla, pp-1-2, ISBN-978-624-5817-02-3

Nadeesha, D. Bandara, M.A.C.S., Munaweerage, T.P. & Shantha W.H.A. (2022). Commercial Organic Fertilizer Production Issues and Prospects, Hector Kobbekaduwa Agrarian Research and Training Institute, Sri Lanka.

Radford, F., Zapata-Restrepo, L.M., Horton, A. A., Hudson, M.D., Shaw, P.J. & Williams, I.D. (2021). Developing a systematic method for extraction of microplastics in soils. *Analytical Methods*, 13(14), pp.1695-1705. DOI: 10.1039/D0AY02086A

Ranasingha, A. S. Y. P., Karunarathna, A. K., Dandeniya, W. S., Nijamudeen, M.S., and Rajapaksha T.N. (2023), Characteristics of Commercial-Scale Agricultural Waste Compost Production Facilities in Sri Lanka, *Annals of Sri Lanka Department of agriculture*, 25, 115-127

Samarasinha, G.G. de L.W., Bandara, M.A.C.S. & Karunarathne, A.K. (2014). Prospects of Municipal Solid Waste Composting, HARTI Research Report No: 174, Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo, Sri Lanka.

Samarasiri, B.K.T., Sinhara, M.H.D., Perera, D. F., & Perera, K.S.S. (2021). Resource Recovery from Organic Fraction of Municipal Solid Waste in Sri Lanka – Current Status and Future Prospects. Current Research in Wastewater Management, 1(1), DOI: 10.31586/wastewater10100

Sato, N., Iida, C., Nishi,. C., & Karunarathna, A. K. (2020). Evaluation of Organic And Recyclable Waste Separation at Generation Source in Ratnapura And Kataragama Local Authorities in Sri Lanka, Detritus, 12, 176-186, doi.org/10.31025/2611-4135/2020.14006

Schothorst, B., Beriot, N., Lwanga, E. H. & Geissen, V. (2021). Sources of Light Density Microplastic Related to Two Agricultural Practices: The Use of Compost and Plastic Mulch. Environments, 8, 36. https://doi.org/10.3390/

Scotti R., Bonanomi, G., Scelza, R., Zoina, A. & Rao, M.A. (2015). Organic amendments as sustainable tool to recovery fertility in intensive agricultural systems, Journal of

Soil Science and Plant Nutrition, 15(2), 333-352. doi.org/10.4067/S0718-95162015005000031

Shim, W., Hong, S. & Eo, S. (2017). Identification methods in microplastic analysis: a review. *Analytical Methods*, The Royal Society of Chemistry 9(9), 1384-1391, DOI: 10.1039/c6ay02558g

Smith, M. (2018). *Do microplastic residuals in municipal compost bioaccumulate in plant tissue?*

M.Sc. Thesis. Faculty of Social and Applied Sciences, Royal Roads University, British Columbia, Canada.

Sri Lanka Standards Institute, (2019). Specification for compost made from municipal solid waste, SLSI 1634:2019.

Sri Lanka Standards Institute, (2019). Specification for compost made from raw materials
of agricultural origin, SLSI 1635:2019.

Vithanage, M., Ramanayaka, S., Hasinthara, S. & Navaratne, A. (2021). Compost as a carrier for microplastics and plastic-bound toxic metals into agro-ecosystems, Current Opinion in Environmental Science & Health, 24, 100297. doi.org/10.1016/j.coesh.2021.100297

Zhang J., Wang X., Xue W., Li Xu, Ding W., Zhao M, Liu S, Zou G, & Chen Y. (2022). Microplastic pollution in the soil increases dramatically with long-term application of organic composts in a wheat–maize rotation. Journal of Cleaner Production, 356, 131889. doi.org/10.1016/j.jclepro. 2022.131889