Assessment of Secondary Microplastic Distribution in the Soil Samples of Selected Sites in District Kangra, Himachal Pradesh

Yogita Thakur
Department of Animal Sciences,
School of Life Sciences,
Central University of Himachal Pradesh,
Shahpur Campus, Kangra
Email: yogitav246@gmail.com

Reshma Sinha
Department of Animal Sciences,
School of Life Sciences,
Central University of Himachal Pradesh,
Shahpur Campus, Kangra
Email: sinhareshma89@gmail.com

Reference to this paper should be made as follows:

Yogita Thakur
Reshma Sinha
"Assessment of Secondary Microplastic Distribution in the Soil Samples of Selected Sites in District Kangra, Himachal Pradesh"

Voyager: Vol. XV,
Sept. 2024 (Special Issue)
Article No. 02
pp.08-17
Similarity Check 11%

Online available at:
www.anubooks.com/

DOI: https://doi.org/10.31995/voyager.2024.v15.SI.002

ABSTRACT

Plastic and its usage have become unanimous in our daily life. The regular plastic in its different forms of usage and upon degradation produces different types of plastics such as mega, micro and nano plastics in the environment. In continuance to this, an attempt has been made to determine the prevalence of microplastic (MPs) in the soil samples from selected sites in Kangra district of Himachal Pradesh. This work investigated the MPs occurrence in five different agricultural sites (Boh Valley, Shahpur, Majhin, Palampur, Nagrota Bagwan) of district Kangra. 100g of soil samples were collected from six discrete sites of each sampling area. The MPs were extracted through density separation approach and counted manually by stereomicroscope. The assessment of abundance was made on the basis of colour and shape of MPs. The results showed the presence of MPs particles in 22 out of 30 collected soil samples. Qualitatively, transparent or colourless (68%) MPs dominated the region followed by green (12%), black (8%), red (4%), blue (4%), and white (4%). Similarly fibrous shaped MPs (68%) were found to be most abundant shape observed followed by fragments (20%), and film shaped microplastic (12%). The number of MPs recorded was highest in Shahpur (48%) followed by Nagrota Bagwan (20%), Majhin (16%), Palampur (8%) and Boh Valley (8%). The size of microplastic examined varied from 0.1mm to 1.2mm. The findings highlighted the pervasive impact of human activities, exemplified by the occurrence of MPs in soil samples and broader implications for environmental conservation.

KEYWORDS

Himachal Pradesh, Kangra, Microplastic, Soil sample, Plastic, Agricultural land, https://doi.org/10.31995/voyager.2024.v15.SI.001

1. INTRODUCTION

The usage of plastic has expanded intensely since 1980s and has resulted in considerable pollution in the environment. Due to properties of these polymers like low production costs, water resistance, high strength, low weight, and high thermal and electrical insulation properties, they are nearly irreplaceable in present day life. Some of the normally used polymers in day-to-day life are: Polyethylene terephthalate (PETH), High density polyethylene (HDPE), Polyvinyl chloride (PVC), Low density polyethylene (LDPE), and Polypropylene (PP) (Ivar do Sul & Costa, 2014). In the last 5 decades, there has been a surge in worldwide plastic production by a factor of 20. The total plastic manufacture was estimated to be 368 million metric tons (Mt) in 2019, with projections indicating a possible doubling within next two decades (Walker & Fequet, 2023). Out of total, only around 9% of the world's plastic waste has been recovered, 12% has been incinerated, while remaining 79% has been found to be accumulated in the natural ecosystem (Geyer *et al., 2017*).

Microplastics (MPs) are very small bits of plastic with a length of <5mm which are insoluble in water (Bergmann *et al.,* 2021). Primary MPs and secondary microplastics are two different forms of MPs. Primary MPs are particles of size 5nm or smaller even before they enter the environment and are being created for specific purposes like in cosmetics or personal care products and used in industrial manufacturing (Karbalaei *et al.,* 2018). On the other hand, secondary microplastic are the plastic particles that result from breakdown of larger plastic goods, such as water bottles. Microplastics in environment can be found in five different kinds on the basis of their morphology such as, microfibers, microbeads, fragments, nurdles, and foam.

MPs contamination in the biosphere has become a hot topic of debate, and it is an intriguing field of research in terms of source, routes and possible toxicity (Berg *et al.,* 2020). Soil is the world's most abundant environment, the primary habitat for both known and unknown bio diversities (Decaens *et al.,* 2006). Occurrence of MPs in soil lowers its bulk density (Xu *et al*., 2020) and disturbs its biophysical characteristics (J. Wang *et al*., 2019). Different plant species has been reported to uptake microbeads and microfibers by roots (Z. Wang *et al*., 2022) and translocate these particles to their stem and leaves *via* vascular system (Li *et al*., 2019). MPs have negative impacts on soil fauna. Data from previous researches show that MPs reduce survival rates, body weight (Rodriguez-Seijo *et al*., 2017) and induce intestinal cells and DNA impairment (Jiang *et al.*, 2020) in earthworms. Understanding the prevalent influence of MPs in soil ecosystem, soil fauna, and the possible risk of human exposure highlights the urgency to assess and quantify their presence in soil. Rigorous evaluation of MP levels is crucial in formulating informed strategies to mitigate environmental contamination.

2. MATERIALS AND METHOD

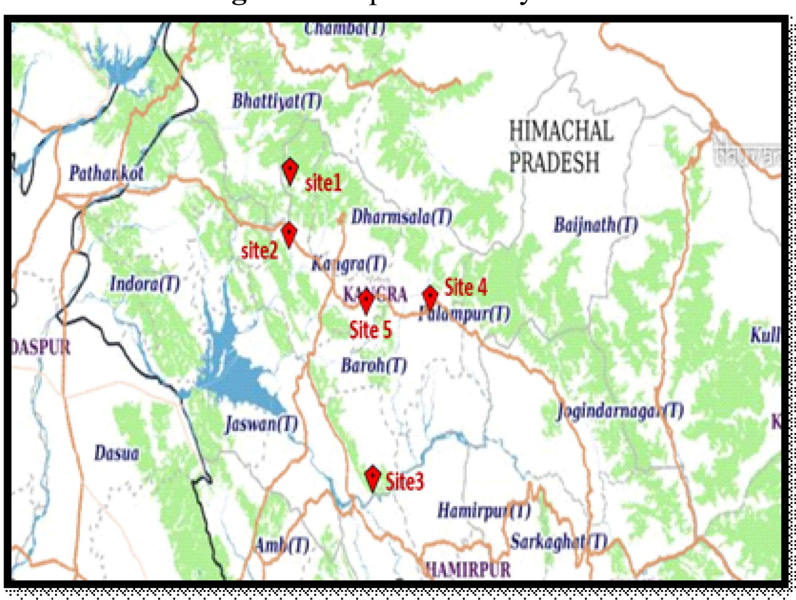
2.1. Study site: The study was carried out in district Kangra of Himachal Pradesh, which is located between 32°13´0´´N latitude 76°19´0´´E longitude with climate varying from subtropical to subtemperate. The present study was conducted in five locations namely, 1) Boh valley 2) Shahpur, 3) Majhin 4) Palampur 5) Nagrota Bagwan (Table 1 Figure 1).

Table: 1. Geo-coordinate of selected sampling sites

Sampling site	Name	Geo-coordinates		Vegetation/ Land used
		Latitude	**Longitude**	
Site 1	Boh valley	32.3125°	76.1877°	Agricultural Field
Site 2	Shahpur	32.2197°	76.1728°	Agricultural field
Site 3	Majhin	31.8232°	76.3941°	Agricultural field
Site 4	Palampur	32.1109°	76.5363°	Agricultural field
Site 5	Nagrota Bagwan	32.1054°	76.3789°	Agricultural field

2.2.Soil sample collection and preparation: 100g of soil samples were collected from six discrete sites of each sampling area (5 sites) making a total of 600g and total of 30 samples

Figure 1. Map of the study sites



https://doi.org/10.31995/voyager.2024.v15.SI.001

The collected samples were transferred to the laboratory in aluminium foil (Moller *et al.,* 2020). The larger soil aggregates were disintegrated manually to separate the incorporated MPs. Before any further sample processing, soil samples were homogenized manually. After homogenization, the soil samples were sieved to fine soil $\leq$2mm (Zhang *et al.,* 2018), and the larger plastic particles were separated.

2.3. Extraction of MPs: To extract the MPs, each soil sample was transferred into the high-density solution (100mL) of saturated NaCl (1.2 g cm^{-3}) in a glass beaker. The suspension was then stirred at 2000 rpm for 5 minutes in centrifuge and left at rest for about 2 hours. After about 2 hours, the denser soil components settled at the bottom and the supernatant underwent filtration using Whatman filter paper (no. 42) and MPs were subsequently collected. Due to similar density of soil organic matter (ρ< 1.6$gcm^{-3)}$ with that of microplastics (ρ=0.9-1.6gcm^{-3}), the organic matter was removed by oxidising the soil sample using 30% H_2O_2 at 70°C for three days (Cerli *et al.,* 2012). After digestion of the soil organic matter the samples were again filtered and washed with water.

2.4. Visualisation of MPs: The filtered samples were then visualised under stereomicroscope (Magnus Ch20I). MPs were characterized and recorded based on their morphology, size and colour. The stereomicroscope was equipped with a digital microscope camera and identification was conducted under 10X and 40X magnification (Ding *et al.,* 2019).

2.5. Control of plastic contamination: Usage of any plastic instruments were avoided throughout the study to prevent plastic contamination of the samples through airborne exposure.

3. RESULTS AND DISCUSSION

All the agricultural soil samples collected were found to be contaminated with microplastic. However, the abundance varied significantly (Figure 2). Microplastic were counted manually and were categorised into various categories typically based on the colours and the shapes.

The microplastics obtained were of various colours such as transparent or colourless (68%), green (12%), black (8%), red (4%), blue (4%), white (4%) (Figure 2, Table 2). More than 65% of the examined MPs were colourless and in concordance with results of Liu *et al.* (2018), where they found transparent and colourless MPs (46.30%) dominating in the deep soil layers of farmland soils in suburban areas of Sanghai, China. Anthropogenic activities such as illegal dumping of plastic, agricultural plastic application like green house, plastic mulching, biowaste compost and application of plastic-containing fertilizers may have contributed significantly to occurrence of coloured MP particles. While decolorization of coloured plastics, transparent disposed plastics, stands out as a possible source of transparent MPs (Zhang *et al., 2*018).

Similarly, according to the shape, the MPs identified were fragment, fibrous, and film shaped (Table 3, Figure 2). The number of microplastic observed was highest in site 2 (Shahpur) and least particles were observed in site 1 (Boh valley) and site 4 (Palampur). Least occurrence of MPs in site 1 and site 2 potentially corelate with reduced anthropogenic activities in these elevated regions.

Table 2. Various coloured MPs obtained from the sampling.

STUDY SITES	GREEN	RED	BLUE	BLACK	WHITE	COLO RLESS	TOTAL
BOH VALLEY	0	0	1	0	0	1	2
SHAHPUR	3	1	0	1	0	7	12
MAJHIN	0	0	0	0	1	3	4
PALAMPUR	0	0	0	0	0	2	2
NAGROTA BAGWAN	0	0	0	1	0	4	5

Table 3. Various shaped of MPs obtained from the sampling.

STUDY SITES	FIBROUS SHAPED	FRAGMENT SHAPED	FILM SHAPED	TOTAL
BOH VALLEY	1	0	1	2
SHAHPUR	7	3	2	12
MAJHIN	3	1	0	4
PALAMPUR	2	0	0	2
NAGROTA BAGWAN	4	1	0	5

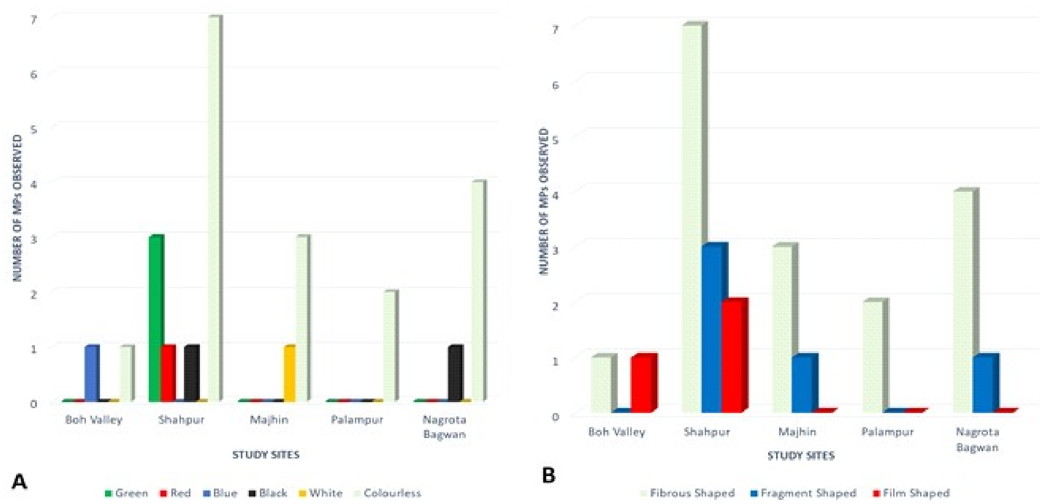


Figure 2. Graph representing A. Colours of MPs B. Shapes of MPs examined

The size of microplastic varied from 0.1mm (black) being the smallest to 1.2mm (white) being the largest particle examined (Figure 3). Previous studies have reported almost similar particle size range of 0.1mm to 2mm from sediment samples from Majalaya district, Indonesia (Alam *et al.,* 2019). In contrast to our findings Huang et al. (2020) reported MPs of size ranging from 100µm to 300µm in all 10-samples collected from the cultivated soil of whole Yunnan Province, China. The observed smaller size of MPs may be attributed to the intensified shearing forces during agricultural activities, particularly ploughing, exacerbating the breakdown of bigger plastic particles into smaller ones. Abundance of MPs identified varied at about 68% fibres followed by fragments (20%) and films (12%). About 68% of the microplastic obtained were fibrous shaped. Concordantly Zhang and Liu, (2018) reported 92% fibres followed by fragments and films (8%) in soil aggregates of Chai River valley, China. In contrast to our findings, Karthikeyan *et al.* (2018) reported fragments (47-50%) in abundance than fibres (24-27%), and foam (10-19%). Furthermore, a different study conducted in costal soils of China observed seven different shapes of MPs, wherein flack-shaped particles accounted for more than 60%, and pellets were least prevalent, comprising only 0.1% of the total observed MPs (Zhou *et al*., 2018). As found in present study fibres to be the most dominating shape which is likely to be closely associated with the higher production and usage of synthetic fibres.

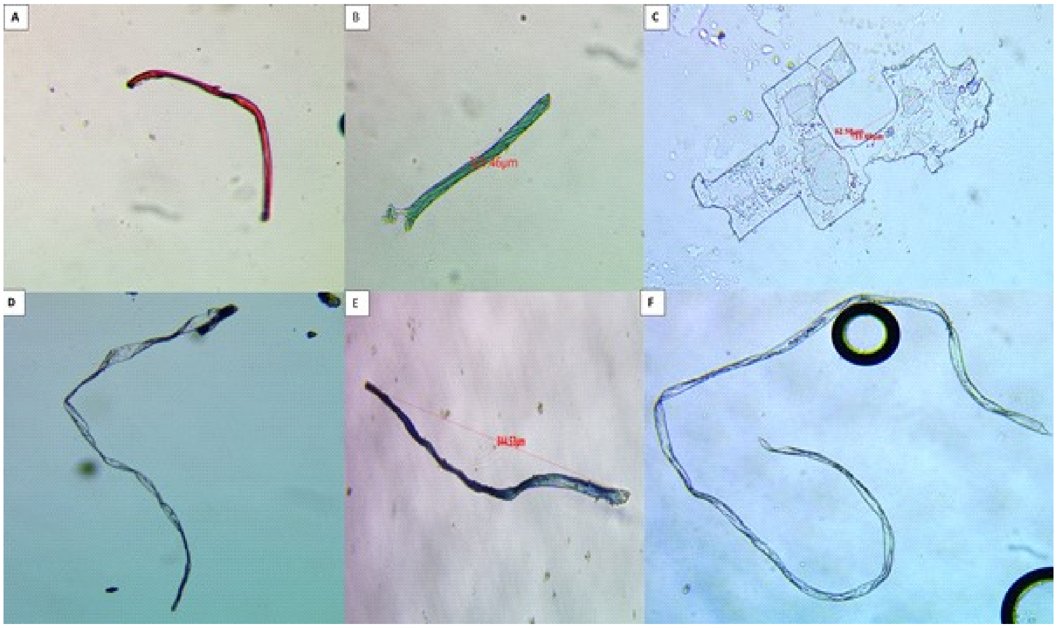


Figure 3. Photographs of microplastic under stereomicroscope A, B, D, E and F (Fibers), C (Fragment shaped)

The occurrence of fragments can be easily linked with plastic bags and plastic waste such as bottles and containers containing fertilizers and pesticides which are common around agricultural areas. A higher abundance of fibres has been reported on other areas also, e.g., Xijin wetland Park, Nanning, South China (Wang *et al.*, 2022), Dongting lake and Hong Lake, China (Wang *et al.,* 2018). In samples collected from a high-altitude site, Boh valley (7000 meters from the sea level), only fibrous and film shaped MP particles which were blue and colourless were found. However, the number of MP particles found was far lesser than the other sites. Concordantly Feng *et al.* (2021), also found transparent and colourless (49.02%) microplastic dominating but in contrast to our study they found film shaped particles in abundance with total percentage of 40.69% followed by fragments (27.4%), fibres (20.5%), foams (7.3%) and spherules (3.9%) in agricultural acreage soils in Qinghai-Tibet Plateau.

CONCLUSION

The complete analysis of MP contamination in agricultural soil across different sites has revealed remarkable results. The study identified more prevalence of secondary MPs such as fragments and fibres while the primary forms like industrial pellets or microbeads were notably absent. Site- specific variations in MPs abundance, notably lower levels at higher altitudes in site 1 (Boh valley) and site 4 (Palampur), suggests a potential correlation with reduced anthropogenic activities in these elevated regions. The prevalence of colourless particles suggests possible bleaching of coloured MPs or use of transparent plastic products. The study highlights how important is to understand the possible sources and distribution of MPs in farming soils. Anthropogenic behaviours like illicit dumping and usage of plastic based agricultural practices were identified as possible sources of contamination. There is an urgent need for a more thorough examination of MPs loads and their fate.

REFERENCES

1. Alam, F. C., Sembiring, E., Muntalif, B. S., & Suendo, V. (2019). Microplastic distribution in surface water and sediment river around slum and industrial area (case study: Ciwalengke River, Majalaya district, Indonesia). *Chemosphere*, *224*, 637-645.https://doi.org/10.1016/j.chemosphere.2019.02.188
2. Bergmann, M., Gutow, L., & Klages, M. (2015). *Marine anthropogenic litter* (p. 447). Springer Nature.https://library.oapen.org/bitstream/handle/20.500.12657/28030/1001966.pdf?sequence=1
3. Cerli, C., Celi, L., Kalbitz, K., Guggenberger, G., & Kaiser, K. (2012). Separation of light and heavy organic matter fractions in soil—Testing for proper density cut-off and dispersion level. *Geoderma*, *170*, 403-416.https://doi.org/10.1016/j.geoderma.2011.10.009
4. Decaëns, T., Jiménez, J. J., Gioia, C., Measey, G. J., & Lavelle, P. (2006). The values of soil animals for conservation biology. *European Journal of Soil Biology*, *42*, S23-S38
5. Ding, L., Zhang, S., Wang, X., Yang, X., Zhang, C., Qi, Y., & Guo, X. (2020). The occurrence and distribution characteristics of microplastics in the agricultural soils of Shaanxi Province, in north-western China. *Science of the Total Environment*, *720*, 137525
6. Feng, S., Lu, H., & Liu, Y. (2021). The occurrence of microplastics in farmland and grassland soils in the Qinghai-Tibet plateau: Different land use and mulching time in facility agriculture. *Environmental Pollution*, *279*, 11693.
7. Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science advances*, *3*(7), e1700782.
8. Huang, B., Sun, L., Liu, M., Huang, H., He, H., Han, F., ... & Pan, X. (2021). Abundance and distribution characteristics of microplastic in plateau cultivated land of Yunnan Province, China. *Environmental Science and Pollution Research*, *28*, 1675-1688.

9. Jiang, X. J., Liu, W., Wang, E., Zhou, T., & Xin, P. (2017). Residual plastic mulch fragments effects on soil physical properties and water flow behavior in the Minqin Oasis, northwestern China. *Soil and Tillage Research*, *166*, 100-107.https://doi.org/10.1016/j.still.2016.10.011

10. Karbalaei, S., Hanachi, P., Walker, T.R. *et al.* (2018). Occurrence, sources, human health impacts and mitigation of microplastic pollution. *Environ Sci Pollut Res* **25,** 36046–36063. https://doi.org/10.1007/s11356-018-3508-7

11. Lei, L., Liu, M., Song, Y., Lu, S., Hu, J., Cao, C., ... & He, D. (2018). Polystyrene (nano) microplastics cause size-dependent neurotoxicity, oxidative damage and other adverse effects in Caenorhabditis elegans. *Environmental Science: Nano*, *5*(8), 2009-2020.

12. Liu, H., Yang, X., Liang, C., Li, Y., Qiao, L., Ai, Z., ... & Liu, G. (2019). Interactive effects of microplastics and glyphosate on the dynamics of soil dissolved organic matter in a Chinese loess soil. *Catena*, *182*, 104177.

13. Liu, S., Wang, J., Zhu, J., Wang, J., Wang, H., & Zhan, X. (2021). The joint toxicity of polyethylene microplastic and phenanthrene to wheat seedlings. *Chemosphere*, *282*, 130967.

14. Lu, Y., Zhang, Y., Deng, Y., Jiang, W., Zhao, Y., Geng, J., ... & Ren, H. (2016). Uptake and accumulation of polystyrene microplastics in zebrafish (Danio rerio) and toxic effects in liver. *Environmental science & technology*, *50*(7), 4054-4060.

15. Moller, J. N., Loder, M. G., & Laforsch, C. (2020). Finding microplastics in soils: a review of analytical methods. *Environmental science & technology*, *54*(4), 2078-2090.

16. Pignattelli, S., Broccoli, A., & Renzi, M. (2020). Physiological responses of garden cress (L. sativum) to different types of microplastics. *Science of the Total Environment*, *727*, 138609Gao, M., Liu, Y., & Song, Z. (2019). Effects of polyethylene microplastic on the phytotoxicity of di-n-butyl phthalate in lettuce (Lactuca sativa L. var. ramosa Hort). *Chemosphere*, *237*, 124482.

17. Rodriguez-Seijo, A., Lourenço, J., Rocha-Santos, T. A. P., Da Costa, J., Duarte, A. C., Vala, H., & Pereira, R. (2017). Histopathological and molecular effects of microplastics in Eisenia andrei Bouché. *Environmental Pollution*, *220*, 495-503.

18. van den Berg, P., Huerta-Lwanga, E., Corradini, F., & Geissen, V. (2020). Sewage sludge application as a vehicle for microplastics in eastern Spanish agricultural soils. *Environmental Pollution*, *261*, 114198.https://doi.org/10.1016/j.envpol.2020.114198

19. Walker, T. R., & Fequet, L. (2023). Current trends of unsustainable plastic production and micro (nano) plastic pollution. *TrAC Trends in Analytical Chemistry*, 116984.Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science advances*, *3*(7), e1700782.

20. Wang, G., Lu, J., Tong, Y., Liu, Z., Zhou, H., & Xiayihazi, N. (2020). Occurrence and pollution characteristics of microplastics in surface water of the Manas River Basin, China. *Science of The Total Environment*, *710*, 136099.https://doi.org/10.1016/j.scitotenv.2019.136099

21. Wang, J., Liu, X., Li, Y., Powell, T., Wang, X., Wang, G., & Zhang, P. (2019). Microplastics as contaminants in the soil environment: A mini-review. *Science of the total environment*, *691*, 848-857.

22. Wang, Q., Huang, K., Li, Y., Zhang, Y., Yan, L., Xu, K., ... & Wang, J. (2022). Microplastics abundance, distribution, and composition in freshwater and sediments from the largest Xijin Wetland Park, Nanning, South China. *Gondwana Research*, *108*, 13-21.

23. Wang, T., Zou, X., Li, B., Yao, Y., Zang, Z., Li, Y. Wang, W., (2019). Preliminary study of the source apportionment and diversity of microplastics: taking floating microplastics in the South China Sea as an example. Environ. Pollut., 245, 965-974.

24. Wang, W., Yuan, W., Chen, Y., & Wang, J. (2018). Microplastics in surface waters of dongting lake and hong lake, China. *Science of the Total Environment*, *633*, 539-545.

25. Wang, Z., Li, S., Jian, S., Ye, F., Wang, T., Gong, L., & Li, X. (2022). Low temperature tolerance is impaired by polystyrene nanoplastics accumulated in cells of barley (Hordeum vulgare L.) plants. *Journal of Hazardous Materials*, *426*, 127826. Li, L., Zhou, Q., Yin, N., Tu, C., & Luo, Y. (2019). Uptake and accumulation of microplastics in an edible plant. *Chinese Science Bulletin*, *64*(9), 928-934.

26. Zhang, S., Yang, X., Gertsen, H., Peters, P., Salánki, T., & Geissen, V. (2018). A simple method for the extraction and identification of light density microplastics from soil. *Science of the Total Environment*, *616*, 1056-1065.https://doi.org/10.1016/j.scitotenv.2017.10.213