A study on the microplastic fibre in the water sample collected from Sassoon dock, west coast of Mumbai, Maharashtra

[1]**Priti Singh**, [2]**Dr. Leena Muralidharan**.

Dept. of Zoology
Ramniranjan Jhunjhunwala College
Mumbai 400086. Maharashtra (India).

Abstract- **The escalating challenges posed by the expanding global population have amplified the gravity of water pollution, emerging as a pivotal concern that demands immediate attention in our rapidly developing world. Aquatic ecosystems are frequently impacted by the presence of microplastic fibers, emerging as pervasive contaminants. Comprehensive scientific analysis revealed the omnipresence of microplastic particles, as they were detected in every single water sample collected from Sassoon dock examined during rainy and post rainy season using stereomicroscope and ATR-FTIR spectroscopic detection method. Notably, microplastic particles ranging from 100 to 500 µm in size and blue colour exhibited a predominant presence, indicating their extensive distribution within the studied ecosystem. This study marks a significant milestone as one of the initial reports to effectively identify and assess the abundance of microplastic particles, offering invaluable insights into their far-reaching implications on the marine organisms inhabiting this specific region of Mumbai, west coast of Maharashtra.**

Keyword: **ATR-FTIR, microplastic fibres, Sassoon dock, stereomicroscope.**

INTRODUCTION

Plastic waste has emerged as an alarming environmental predicament of utmost significance (Shen, C., et al., 2021). Plastics have emerged as a notable and distinct constituent within the global sedimentary system, displaying a wide distribution encompassing mountainous regions to the depths of oceanic trenches. Their pervasive presence establishes plastics as one of the most prevalent and pervasive forms of pollution within coastal and marine ecosystems on a global scale (De-la-Torre G. E.,2020). Microplastics have become a global concern due to their widespread presence, even in remote regions such as the waters of Antarctica (Cincinelli, A., et al., 2017) and the Arctic Ocean (Cózar, A., et al., 2017). The degradation process of plastics is characterized by its prolonged and slow nature, as they gradually break down into minute particles through mechanisms such as natural weathering, bioremediation, or photo-oxidative degradation over an extended period of time. These resulting particles, measuring less than 5 mm in size, are commonly referred to as microplastics (Jemec Kokalj, A., et al., 2018). Microplastics, characterized as plastic particles smaller than 5 mm, have emerged as the predominant form of human-generated litter in marine habitats worldwide. This pervasive contamination is a direct consequence of the escalating production and insufficient management of single-use plastic items, coupled with the fragmentation of larger plastic debris. As a result, the prevalence of microplastics is steadily increasing, posing significant environmental concerns and underscoring the urgent need for effective mitigation strategies (Jambeck et al., 2015). Microplastic particles, ranging in size from 0.5 to 5 mm, exhibit a widespread distribution in aquatic ecosystems, existing in substantial quantities. Once introduced into the food chain, these microplastics pose a significant risk by inducing toxicity in various organisms. Notably, microplastics have the potential to enter the human food chain through two primary pathways: consumption of contaminated fish and ingestion of microplastic-contaminated drinking water (Sharma, A., et al.,2023). Agricultural practices, industrial operations, and domestic waste contribute to the terrestrial sources of microplastics. These land-based microplastics find their way into marine environments through processes such as groundwater runoff or tidal action, as highlighted by Luo et al. (2021). These diverse sources contribute significantly to the accumulation of plastic pollution in our oceans.

The presence of contaminants, including microplastics has adversely impacted the health and nutritional composition of diverse marine organisms, notably fish, leading to compromised well-being and nutritional quality within these populations (Subaramaniyam U, et al., 2023). In a study conducted by Boháčková et al. in 2023, it was noted that rainbow trout subjected to plastic additives exhibited a significant elevation in oxidative stress biomarkers, indicating a pronounced impact on their physiological responses (Boháčková, J., et al., 2023). According to Lebreton, L. C. M., et al., annually, a substantial influx of plastic waste enters the ocean via river systems, with a noteworthy 74% of these emissions occurring during the period between May and October. The concentration of this issue is primarily concentrated in the top 20 polluting rivers, predominantly situated in Asia, collectively responsible for 67% of the global plastic waste input into marine environments (Lebreton, L. C. M., et al.,2017).

To address the knowledge gap regarding microplastic fiber contamination in Sassoon dock water, we conducted a comprehensive study aiming to detect and analyze the presence of microplastics in this specific region of the Arabian Ocean. Leveraging the combined capabilities of stereomicroscopy and ATR-FTIR spectroscopy, our study design enabled us to investigate the distribution patterns and the concentrations of microplastics within the designated study zone. By employing these scientific methodologies, we aimed to contribute valuable insights into the extent of microplastic pollution in this marine environment and enhance our understanding of the potential ecological implications

MATERIALS AND METHOD

A. Sample collection

Sassoon dock, a renowned and historic dock in Mumbai, occupies a significant geographic position, positioned between latitude 18°54'37.692" N and longitude 72°49'2.172" E (Fig. 1). Collaborating closely with local fishermen operating in the vicinity of Sassoon dock, water samples were systematically collected from the middle layer of the site to avoid any superficial contamination during the rainy and post rainy season of year 2022. To minimize the potential influence of airborne microplastic contamination, the fishermen were instructed to extract water samples from the intermediate layer of the sea, strategically avoiding the superficial layer. The water samples were digested as per Cai, H., et al. described for microplastic analysis (Cai, H., et al., 2021).

Fig. 1 Sassoon dock site from where water sample is collected

B. Detection Methodology:

1. Stereomicroscope: A stereomicroscope was employed to conduct a meticulous examination of microplastic particles, enabling the screening process to determine their abundance and morphological characteristics, such as shape, size, and color (Khan, M. B.,et al., 2018)

2. Attenuated Total Reflectance Fourier-Transform Infrared Spectroscopy (ATR-FTIR): Each microplastic fiber particle identified during the screening phase was individually selected for further analysis. Utilizing ATR-FTIR spectroscopy, the selected particles were subjected to spectral analysis to determine their composition (Tang, Q., et al., 2021). The ATR-FTIR spectroscope's integrated spectral library search function facilitated the comparison of the obtained spectra with known references, aiding in the identification of the specific microplastic fibers present.

3. Complete recovery: In order to achieve the highest possible recovery rate and ensure precise and reliable results, a rigorous approach was adopted, involving the repetition of the microplastic isolation procedure three times for each individual sample. This meticulous repetition was undertaken with meticulous care and attention to detail, guaranteeing comprehensive retrieval of microplastics and upholding the utmost accuracy in the subsequent.

4. Contamination prevention: After each sample filtration, the entire system was thoroughly rinsed using ultrapure water and 70% ethanol to eliminate any residue and avoid cross-contamination analysis and findings also processing was done under closed room.

OBSERVATION AND RESULT

Notably, microplastic fibers were consistently present in 100% of the water samples collected from Sassoon dock. During the analysis of water samples collected from Sassoon dock during the rainy season, it was determined that the samples contained an average of 7.5 ± 0.5 microplastic particles per liter of water sample. The identified microplastic fibers in the samples consisted of various polymer types, with polyethylene comprising 33.8% of the total, followed by high-density polyethylene (4.5%), polypropylene (30.2%), polystyrene (6%), and polyamide (25.5%) (Table number 1). The prevalence of polyethylene, polypropylene, and polyamide indicated their significant abundance in the water body. The size range of the microplastic particles detected varied from 0.1 mm to 10 cm, with particles larger than 5 mm excluded and disregarded for this specific microplastic analysis. The shape of the microplastics predominantly exhibited long, slender forms and comma shapes (Fig.2). In terms of colour (as depicted in Fig. 3), blue microplastics were the most prevalent (41.1%), followed by black (17.4%), colorless (28.6%), red (8.3%), and pink (4.6%).

The analysis of water samples collected from Sassoon dock during the post-rainy season consistently revealed the presence of microplastic fibers in every sample (100% prevalence). The concentration of microplastic particles in the water samples was measured to be 5.2 ± 0.2 particles per liter. The identified microplastic fibers in the samples consisted of various polymer types, with polyethylene accounting for 26.4% of the total, followed by high-density polyethylene (3.7%), polypropylene (25.3%), polystyrene (15.3%), PVC (5.3%), and polyamide (24%) (Table number 1). Polyethylene, polypropylene, and polyamide were consistently found in the majority of the samples. The size range of the microplastic particles detected in the water samples varied from 0.1 mm to 5 mm. The colour analysis (as depicted in Fig.4) indicated that blue microplastics were the most dominant (40.4%), followed by black (29.1%), colorless (20.5%), red (3.7%), and orange (6.3%).

Sample	**Polymer type**	**Microplastic fibres/litre**	**Colour**	**Analytical method used**
Water (Rainy season)	PE, PP, PS, HDPE, PA	7.5 ± 0.5 Fibre/L	Blue, Red, Pink, Black and colourless	Streomicroscope sorting and counting, ATR-FTIR
Water (post Rainy season)	PE, PP, PS, HDPE, PA	5.5 ± 0.5 Fibre /L	Blue, Red, Black, Colourless , Orange	Streomicroscope sorting and counting, ATR-FTIR

Table No. 1. Seasonal variation in number of microplastic fibres/litre of water sample collected from sample site Sassoon dock water, Mumbai.

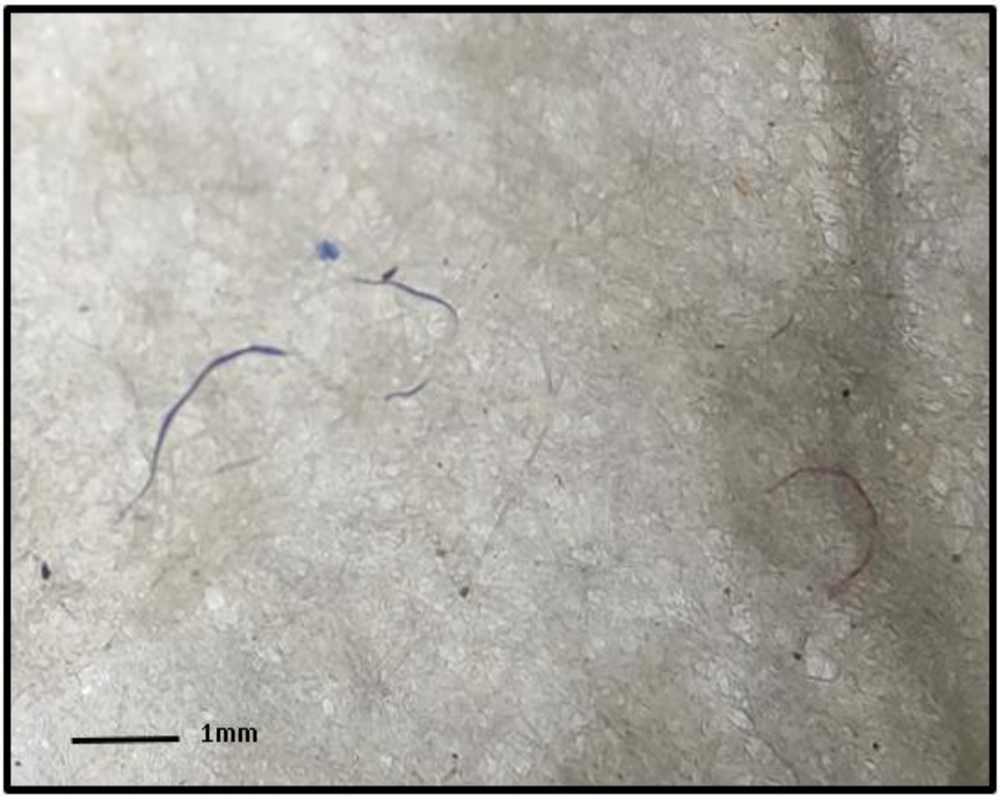

Fig. 2 Microplastic fibre found in water sample of Sassoon dock, Mumbai.

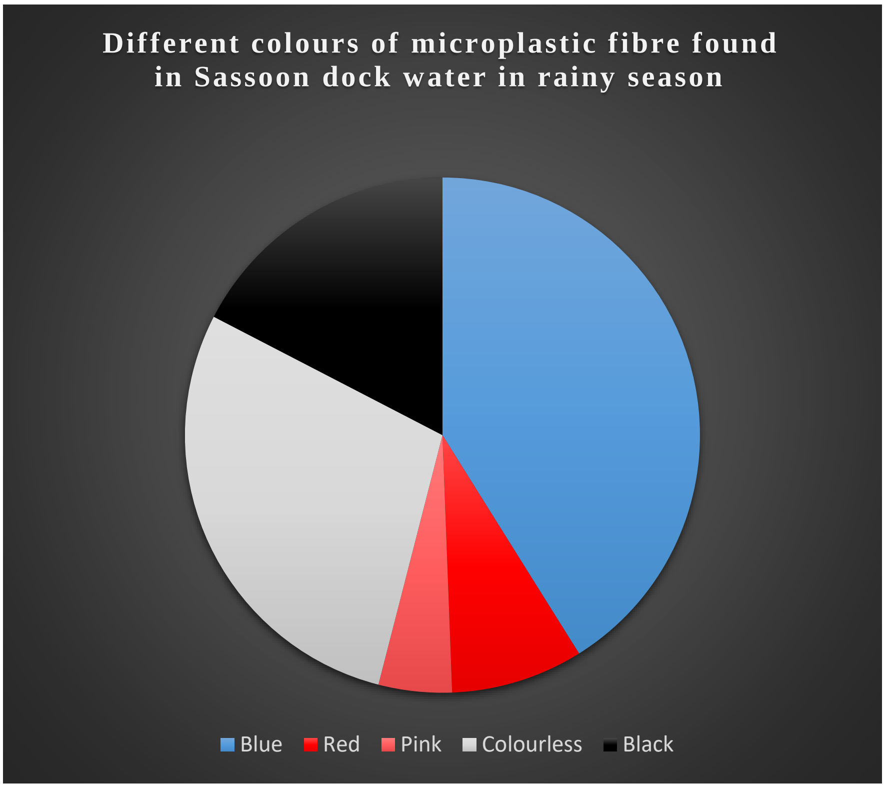

Fig.3 Pie chart illustrating different proportion of colourful microplastic fibres detected in the water sample collected from Sassoon dock during rainy season

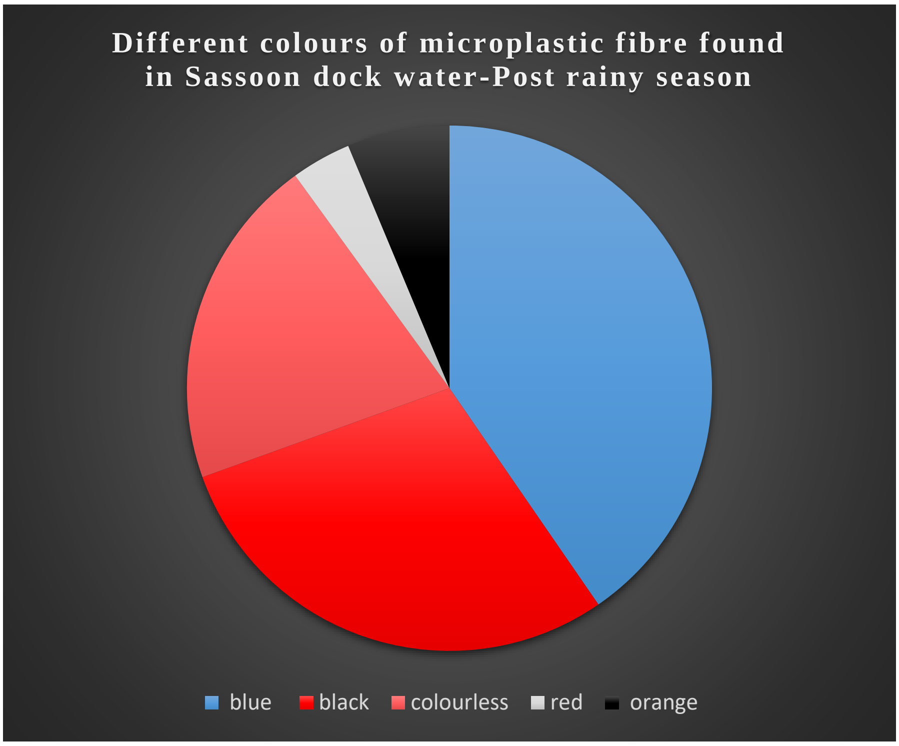

Fig.4 Pie chart illustrating different proportion of colourful microplastic fibres detected in the water sample collected from Sassoon dock during post rainy season

The pie chart illustrates the diverse range of colours present in microplastic fibers found in the water of Sassoon dock during the rainy season and post-rainy season of the experimental period (Fig. 3 and 4). The chart provides a visual representation of the various hues that compose the microplastic pollution, offering valuable insights into the composition and potential sources of these fibers in the marine environment.

DISCUSSION

Our research revealed the consistent presence of microplastic fibers in every water sample collected during both the rainy and post-rainy seasons from the research site. Interestingly, we observed a more pronounced concentration of microplastic fibers during the rainy season as compared to post rainy season. Furthermore, among the detected fibers, those exhibiting a blue colour were found to be the most prevalent in both seasons. These findings emphasize the persistent nature of microplastic pollution in aquatic environments, with variations in concentration and color composition influenced by seasonal factors such as rainfall. Wei, Y., et al., also found similar result as more microplastic fibres of polymers (PE and PP) during rainy season in Xincun Bay, China and also documented that distribution and abundance of microplastics are influenced by seasonal variations as well (Wei, Y., et al.,2022). This phenomenon underscores the significance of rainfall as a contributing factor to the dispersion and distribution of MPs within aquatic ecosystems. Recognizing the impact of precipitation on the movement of MPs is vital for devising comprehensive approaches that effectively address the influx of these pollutants into our water bodies and marine ecosystems. A study conducted by Cai, C et al., review on microplastic (MP) transport processes they found critical elements such as vertical velocity, biofouling, degradation, fragmentation, beaching, and washing-off are the factors emerged as pivotal in determining the intricate movement and ultimate fate of microplastics within aquatic environments (Cai, C et al., 2023). In our study we also found that polyethylene and polypropylene types of microplastic was more pronounced. The widespread use of polypropylene and polyester in the textile industry presents compelling scientific evidence linking wastewater effluent, which contains microfibers from clothes washing (Napper, I. E.,et al., 2016), to significant contributions of microplastics in coastal waters. Furthermore, the degradation of fishing gear (Welden, N. A.,et al., 2017) has also been identified as a significant source of microplastics in these marine environments. These findings emphasize the need to address both textile-related microfibers and the disposal of fishing gear to effectively mitigate the release of microplastics into coastal ecosystems. Our research aligns with the findings of Feng, Q., et al., 2023, who also observed high concentrations of polyethylene and polypropylene in water of river mouth (Feng, Q., et al., 2023). Our research findings are in concordance with the findings of Kor, K., et al., (2020), who similarly reported significant proportions of polyethylene and polypropylene in their investigations. These consistent outcomes reinforce the prevalence of these particular types of microplastics and emphasize the need for continued attention and efforts to address the environmental impact of these persistent materials. Our research findings are corroborated by Green, Dannielle S., et al. (2018), who conducted a study in which they also identified microplastic litter in coastal waters around Ascension Island and the East Falklands. Their investigation revealed that microplastic particles were present in every sampled site, with concentrations ranging from 0.4 to 9 particles per litre. Moreover, the majority of the microplastics collected were in the form of fibers, primarily composed of polyethylene and polypropylene. Aliabad, M. K., et al also found PE and PP types of polymer fibres of microplastic in the surface waters of Chabahar Bay, Gulf of Oman. These parallel outcomes provide additional evidence of the widespread distribution of microplastics and the dominance of specific polymer types in these coastal environments.

CONCLUSION

To conclude, our study sheds light on the previously unexplored issue of microplastic pollution in the water of Sassoon dock, a crucial economic and ecological hub in the Mumbai region that serves as a gateway for seafood exports to both local and international markets. Through meticulous analysis, we successfully generated significant data revealing the presence of microplastic fibers in the study site. Furthermore, our findings demonstrated distinct seasonal variations, with higher concentrations of microplastics during the rainy season compared to the post-rainy season. Seasonal dynamics exert a significant impact on the distribution and abundance of microplastics, contributing to their varying patterns throughout the year. Notably, blue-colored microplastic fibers and microplastics composed of polyethylene and polypropylene emerged as the most abundant types within the study area. It is imperative to disseminate this knowledge to local communities residing in the vicinity, emphasizing the harmful impacts of microplastic pollution on the delicate marine ecosystem. Moreover, proper waste disposal protocols should be implemented to address this issue effectively and safeguard the long-term health of the Sassoon dock and its connected Arabian Sea environment.

Acknowledgement

Authors are thankful to Dr. Himanshu Dawda sir for proving continuous support and ATR- FTIR facilities at the laboratory for the research work.
ACKNOWLEDGEMENT: We are greatful to our principal Dr.Himanshu Dawda sir for providing ATR-FTIR laboratory facility and motivating us throughout the experimental period.

REFERENCES:

1. Aliabad, M. K., Nassiri, M., & Kor, K. (2019). Microplastics in the surface seawaters of Chabahar Bay, Gulf of Oman (Makran Coasts). *Marine pollution bulletin*, 143, 125–133.
2. Boháčková, J., Havlíčková, L., Semerád, J., Titov, I., Trhlíková, O., Beneš, H., & Cajthaml, T. (2023). In vitro toxicity assessment of polyethylene terephthalate and polyvinyl chloride microplastics using three cell lines from rainbow trout (Oncorhynchus mykiss). *Chemosphere*, 312(Pt 1), 136996.
3. Cai, C., Zhu, L., & Hong, B. (2023). A review of methods for modeling microplastic transport in the marine environments. *Marine pollution bulletin*, *193*, 115136. Advance online publication.
4. Cai, H., Du, F., Zhang, W., & Shi, H. (2021). Research Progress of Microplastics and Nanoplastics in Environment. Res. *Environ. Sci.* 34, 2547–2555.
5. Cincinelli, A., Scopetani, C., Chelazzi, D., Lombardini, E., Martellini, T., Katsoyiannis, A., Fossi, M. C., & Corsolini, S. (2017). Microplastic in the surface waters of the Ross Sea (Antarctica): Occurrence, distribution and characterization by FTIR. *Chemosphere*, *175*, 391–400.

6. Cózar, A., Martí, E., Duarte, C. M., García-de-Lomas, J., van Sebille, E., Ballatore, T. J., Eguíluz, V. M., González-Gordillo, J. I., Pedrotti, M. L., Echevarría, F., Troublè, R., & Irigoien, X. (2017). The Arctic Ocean as a dead end for floating plastics in the North Atlantic branch of the Thermohaline Circulation. *Science advances*, *3*(4), e1600582.
7. De-la-Torre G. E. (2020). Microplastics: an emerging threat to food security and human health. *Journal of food science and technology*, *57*(5), 1601–1608.
8. Feng, Q., An, C., Chen, Z., Lee, K., & Wang, Z. (2023). Identification of the driving factors of microplastic load and morphology in estuaries for improving monitoring and management strategies: A global meta-analysis. *Environmental pollution (Barking, Essex : 1987)*, *333*, 122014. Advance online publication.
9. Green, D. S., Kregting, L., Boots, B., Blockley, D. J., Brickle, P., da Costa, M., & Crowley, Q. (2018). A comparison of sampling methods for seawater microplastics and a first report of the microplastic litter in coastal waters of Ascension and Falkland Islands. *Marine pollution bulletin*, *137*, 695–701.
10. Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Marine pollution. Plastic waste inputs from land into the ocean. *Science (New York, N.Y.)*, *347*(6223), 768–771.
11. Jemec Kokalj, A., Horvat, P., Skalar, T., & Kržan, A. (2018). Plastic bag and facial cleanser derived microplastic do not affect feeding behaviour and energy reserves of terrestrial isopods. *The Science of the total environment*, *615*, 761–766.
12. Khan, M. B., & Prezant, R. S. (2018). Microplastic Abundances in a Mussel Bed and Ingestion by the Ribbed Marsh Mussel Geukensia Demissa. Mar. Pollut. Bull. 130, 67–75.
13. Kor, K., & Mehdinia, A. (2020). Neustonic microplastic pollution in the Persian Gulf. *Marine pollution bulletin,* 150, 110665.
14. Lebreton, L. C. M., van der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature communications*, *8*, 15611.
15. Luo, Y., Shi, H., Tu, C., Zhou, Q., Ji, R., Pan, X., Xu, X., Wu, C., An, L.,Sun, X., He, D.,Li, Y.,Ma, Y.,& Li, L.,.(2021). Research progresses and prospects of microplastics in the environment. *Chinese Science Bulletin*. 66, 1547-1562.
16. Napper, I. E., & Thompson, R. C. (2016). Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of fabric type and washing conditions. *Marine pollution bulletin*, *112*(1-2), 39–45.
17. Sharma, A., Kumari, S., Chopade, R. L., Pandit, P. P., Rai, A. R., Nagar, V., Awasthi, G., Singh, A., Awasthi, K. K., & Sankhla, M. S. (2023). An assessment of the impact of structure and type of microplastics on ultrafiltration technology for microplastic remediation. *Science progress*, *106*(2), 368504231176399.
18. Shen, C., Deng, Y., Zhang, J., & Zhang, C. (2021). Improve Life Cycle Management of Plastic Pollution in China. Res. *Environ. Sci*. 34, 2026–2034.
19. Subaramaniyam U, Allimuthu RS, Vappu S, Ramalingam D, Balan R, Paital B, Panda N, Rath PK, Ramalingam N & Sahoo DK (2023), Effects of microplastics, pesticides and nano-materials on fish health, oxidative stress and antioxidant defense mechanism. *Front. Physiol.* 14:1217666.
20. Tang, Q., Li, Q., Wang, J., Zhang, Y., & Gao, X. (2021). Identification and Analysis of Microplastics by Micro Fourier Transform Infrared Spectroscopy. *China Plastics* 35, 172–180.
21. Welden, N. A. & Cowie, P. (2017) Degradation of common polymer ropes in a sublittoral marine environment. *Marine Pollution Bulletin*, 118(1- 2), 248 - 253.
22. Wei, Y., Ma. W., Xu, Q., Sun, C., Wang, X., & Gao, F., (2022). Microplastic Distribution and Influence Factor Analysis of Seawater and Surface Sediments in a Typical Bay With Diverse Functional Areas: A Case Study in Xincun Lagoon, China. Front. *Environ. Sci*. 10:829942.