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The Impacts of Microplastics to Environment

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In today's world, plastic litter has been positioned in the expanded list of worldwide threats, counting climate change and ozone depletion [1]. Plastic debris is regularly separated into two categories: macro plastics and micro plastics. Macro plastic is a well-known worldwide issue potentially causing negative impacts on both the life forms and environment, counting trap, ingestion, retention of harmful chemicals, and transportation of obtrusive species. Macro plastics are known threat to human society and the economy [2,3], while micro plastics are regularly received less consideration. In recent years, it has taken note that impacts caused by microplastics are comparatively more critical than those caused by macro plastics, so there have been increasing environmental concern about tiny plastics.

Microplastics are defined to be the plastic particles between 1 nm to <5 mm in diameter. They are originated from fragmented macro plastics by mechanical abrasion and UV exposure [4], man-made fibers for textiles releasing from domestic washing [5], microplastics used in consumer and cosmetic products, e.g. facial cleaners, toothpaste and etc [6]. These debris resulting from the disposal and breakdown of consumer products, and industrial waste are found in oceans, estuaries, bodies of freshwater and even in the tap water is now well established [7-13]. Due to its light weight, plastic litter transported by winds and currents, and recirculates between seawater and beach sediments. Polymer density is an important determinant for microplastics circulation [14]. Microplastics would cause entanglement and ingestion by a range of marine organisms such as zooplankton, fish, seabirds, sea turtles, crustaceans and mammals has been documented [15]. Smaller microplastics were found to cause higher toxicity to algae [16]. The adsorption of toxic polycyclic aromatic hydrocarbon [17], heavy metals [18] and pathogens [19] on microplastics promoted the negative impacts to marine organisms, probably via the increase in oxidative stress [20] and reduction of nutrient uptake [21]. Microplastics introduce harmful impacts at the tissue and cellular level, and meddled with energy reallocation, reproductive success, and sibling execution [22,23], which pose a threat to biodiversity and environments [2]. Although identified as an emerging environmental threat to the freshwater ecosystems and its ecological consequence. Wastewater treatment plant effluents represent an important point source for micro plastic particles for freshwater environments [24,25].

Presently, there are no standardized protocols for surveying, measuring and monitoring micro plastics in natural ecosystems [26,27]. A standardized method for microplastics measurement is required for data comparability, which should be in low cost and with capability for high volume throughput with acceptable accuracy. Current common approaches to quantify microplastics from sediment would involve multiple steps, including drying to reduce volume, followed by separation, and confirmed by analytic equipment. Separation could be carried out by density separation, filtration, and visual sorting [28]. Visual sorting is time consuming and introduces a lot of false identification. As microplastics are light, floatation techniques using super saturated NaCl [29], sodium nitrate/sodium thiosulfate (SNT) solution [30], Zinc chloride solution [25] were commonly used. Filtration using discfilter with rapid sand filtration and air floatation was introduced in the final stage of municipal wastewater treatment [31]. Additional pre-separation digestion with enzyme [32], acids or chemicals [33] to remove attached organic material without damaging the microplastics would improve the extraction and analysis. The isolated microplastics would then be analyzed by advanced analytical equipment, such as micro-Fourier-transform infrared (micro-FT-IR) spectroscopy, focal plane array (FPA)-based transmission micro-FT-IR imaging [25], raman spectroscopy [34], pyrolysis gas chromatography/mass spectrometry [35], thermal desorption gas chromatography mass spectrometry [36], field-portable-X-ray fluorescence (FP-XRF) spectrometry [18], Nuclear Magnetic Resonance (NMR) [37] and TGA-DSC [38]. They have been employed to detect microplastics in marine habitats by identifying the molecular construction of different plastic types from other materials, which would reduce 22 to 90% of false identification [39]. To use alkaline and wet peroxide oxidation chemical digestion techniques to remove microplastics and followed by looking at the loss of signal in analysis provided an alternative approach to quantify Microplastics [40]. Apart from using advanced analytical equipment, simple method using florescence dye e.g. Nile red was reported to have comparable result of FTIR with 98% recovery rate [41].

More than 300 million tons of plastic are made each year worldwide. This includes polyethylene terephthalate (PET), Polyethylene (PE), Polyvinyl Chloride (PVC), Polystyrene (PS). Equally it is hardly biodegradable, although their degradation can be speed up by UV exposure [42]. However, the process of photo aging is slow, approximately release 3% of content after 2000 hour of photo aging [43]. PE and PS are relatively easier to be degraded in natural environment [44]. However, they can be found even decades later as plastic litter and micro plastic, especially PET is mainly found in all forms of plastic bottles and promotional material. Approximately 51 million tons of PET was produced worldwide in 2014 [45].

According to Microbial degradation of plastics has been provided by [46-48]. There is very little earlier study on the biological degradation of plastic litter or its utilization to support microbial growth. This brings out a whole range of both terrestrial and marine microbial species capable of the degradation activity. Several species of bacteria and fungi have been set apart, showing degradation properties of different cases of plastic polymers. Rare examples include members of the filamentous fungi Fusarium oxysporum and Fusarium solani, which have been shown to grow on a mineral medium containing PET yarns [49]. Recent reports have found marine fungus *Zalerion maritimum* is capable to utilize PE [37], while bacterial isolates of

Bacillus cereus and *Bacillus gottheilii* degrade UV-treated microplastics [50]. Consequently, plastics being resistant to degradation need certain pre-treatment like photo-oxidation or hydrolysis or enzymatic degradation by microorganisms, before the polymers can be metabolized by the beings. Thus, microbes are known to initiate the process of degradation of marine plastic through the organization of a biofilm and secretion of extracellular enzymes to aid in breaking down of plastic polymers (Table 1).

In conclusion, a huge body of knowledge exists for degradation capabilities by microbes; there is even a lack of technological and real time applications of these biological processes in the surroundings. Plastic bioremediation studies suffer from a major limitation, the recalcitrant nature of plastic polymers, which need extra discussion. This treatment could be either chemical or physical methods that could develop down the polymer chains and help speed up the biological processes. Such treatments can generally be enzyme responsible for this degradation may lead to cost-effective and environmentally conscious method for degrading micro plastic. A framework of standard for "Ecocyclable in natural carbon cycle" related to toxicity, bioaccumulation and degradation/assimilation is highly suggested [51-53].

Type of Plastic	**Species**	**Reference**
Polyethylene terephthalate	Ideonella sakaiensis	Yoshida et al., [54]
Polycaprolactone	Pseudozyma jejuensis	Seo et al., [55]
Polyethylene	Pseudomonas sp	Sudhakar et al., [56]
Polyethylene	Enterobacter asburiae & Bacillus sp. Zalerion maritimum	Jun Yang et al., [57] Paço et al., [36]
Bisphenol A (BPA)	Pseudomonas sp	Artham & Doble et al., [58]
Low Density Polyethylene	Aspergillus versicolor	Pramila & Ramesh [59]
Low Density Polyethylene	Chamaeleomyces viridis	Anudurga Gajendiran et al., [60]
polyester	Geomyces pannorum	Cosgrove et al., [61]
Polyester polyurethane	Pestalotiopsis microspore	Russell et al., [62]
Polyethylene	Bacillus cereus	Sudhakar et al., [63]
Polyethylene	Brevibacillus borstelensis	Hadad et al., [64]
Polystyrene	Rhodococcus ruber	Mor and Sivan [65]

Table 1: Biological degradation of plastics.

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References

1. Amaral-Zettler LA, Zettler ER, Slikas B, Boyd GD, Melvin DW, et al. (2015) The Biogeography of the Plastisphere: Implications for Policy. Front Ecol Environ 13: 541–546.
2. Anderson A, Park BJ, Palace VP (2016) Microplastics in aquatic environments: Implications for Canadian ecosystems. Environ Pollut 218: 269-280.
3. Gajendiran A, Khare K, Chacko AM, Abraham J (2016) Fungal mediated degradation of low density polyethylene by a novel strain Chamaeleomyces viridis JAKA1. RJPBCS 7: 3123-3130.
4. Artham T, Doble M (2009) Fouling anddegradation of polycarbonate in seawater: Field and lab studies. J Polym Environ 17:170-180.
5. Auta HS, Emenike CU, Fauziah SH (2017) Screening of bacillus strains isolated from mangrove ecosystems in Peninsular Malaysia for microplastic degradation. Environ Pollut 231: 1552-1559.
6. Bandow N, Will V, Wachtendorf V, Simon F (2017) Contaminant release from aged microplastic. Environ Chem 14: 394-405.
7. Biginagwa FJ, Mayoma BS, Shashoua Y, Syberg K, Khan FR (2016) First evidence of microplastics in the African Great Lakes: Recovery from Lake Victoria Nile perch and Nile tilapia. J Great Lakes Res 42: 146-149.
8. Blumenröder J, Sechet P, Kakkonen JE, Hartl MGJ (2017) Microplastic contamination of intertidal sediments of Scapa Flow, Orkney: A first assessment. Mar Pollut Bull 124: 112-120.
9. Browne MA, Crump P, Niven SJ, Teuten E, Tonkin A (2011) Accumulation of microplastic on shorelines worldwide: Sources and Sinks. Environ Sci Technol 45: 9175-9179.
10. Cole M, Lindeque P, Halsband C, Galloway TS (2011) Microplastics as contaminants in the marine environment: A review. Mar Pollut Bull 62: 2588–2597.
11. Cosgrove L, McGeechan PL, Robson GD, Handley PS (2007) Fungal communities associated with degradation of polyester polyurethane in soil. Appl Environ Microbiol 73: 5817–5824.
12. Dehaut A, Cassone A, Frère L, Hermabessiere L, Himber C, et al. (2016) Microplastics in seafood: Benchmark protocol for their extraction and characterization. Environ Pollution. 215: 223-233.
13. Dümichen E, Eisentraut P, Bannick CG, Barthel A, Senz R, et al. (2017) Fast identification of microplastics in complex environmental samples by a thermal degradation method. Chemosphere 174: 572-584.
14. Eubeler JP, Bernhard M, Knepper TP (2010) Environmental biodegradation of synthetic polymers: II. Biodegradation of differentpolymer groups. Trends Anal Chem 29:84-100.

15. Free CM, Jensen OP, Mason SA, Eriksen M, Williamson NJ (2014). High-levels of microplastic pollution in a large remote, mountain lake. Mar Pollut Bull 85: 156-166.
16. Gall SC, Thompson RC (2015). The impact of debris on marine life. Mar Pollut Bull 92: 170–179.
17. GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection) (2010) Report of the thirty-seventh session of GESAMP, Bangkok, 14 – 19 February 2010. Rep Stud GESAMP 81: 109.
18. Graca B, Szewc K, Zakrzewska D, Dołęga A, Szczerbowska-Boruchowska M (2017) Sources and fate of microplastics in marine and beach sediments of the Southern Baltic Sea-a preliminary study. Environ Sci & Pollut Res. 24: 7650-7661.
19. Gregory MR (2009). Environmental implications of plastic debris in marine settings: entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions Philos Trans R Soc Lond B Biol Sci 364: 2013-2025.
20. Hadad D, Geresh S, Sivan A (2005) Biodegradation of polyethylene by the thermophilic bacterium Brevibacillus borstelensis. J Appl Microbiol 98: 1093–1100.
21. Yang J, Yang Y, Wu WM, Zhao J, Jiang L (2014). Evidence of Polyethylene Biodegradation by Bacterial Strains from the Guts of Plastic-Eating Waxworms. Environ Sci Technol 48: 13776–13784.
22. Karlsson TM, Vethaak AD, Almroth BC, Ariese F, van Velzen M, et al. (2017) Screening for microplastics in sediment, water, marine invertebrates and fish: Method development and microplastic accumulation. Mar Pollut Bull 122: 403-408.
23. Leslie HA, Brandsma SH, van Velzen MJ, Vethaak AD (2017) Microplastics en route: Field measurements in the Dutch river delta and Amsterdam canals, wastewater treatment plants, North Sea sediments and biota Environ Int 101: 133–142.
24. Li W, Tse H, Fok L (2016) Plastic waste in the marine environment: A review of sources, occurrence and effects. Sci Total Environ 566: 333–349.
25. Lima ARA, Barletta M, Costa MF (2015). Seasonal distribution and interactions between plankton and microplastics in a tropical estuary. Estuar Coast Shelf Sci 165: 213-225.
26. Lots FAE, Behrens P, Vijver MG, Horton AA, Bosker T (2017) A large-scale investigation of microplastic contamination: Abundance and characteristics of microplastics in European beach sediment. Mar Pollut Bull 123: 219-226.
27. Lucas N, Bienaime C, Belloy C, Queneudec M, Silvestre F, et al. (2008) Polymer biodegradation: Mecha-nisms and estimation techniques. Chemo-sphere 73: 429-442.
28. Manalu AA, Hariyadi S, Wardiatno Y, (2017) Microplastics abundance in coastal sediments of Jakarta Bay, Indonesia. AACL Bioflux 10: 1164-1173.
29. Majewsky M, Bitter H, Eiche E, Horn H (2016) Determination of microplastic polyethylene (PE) and polypropylene (PP) in environmental samples using thermal analysis (TGA-DSC). Science of the Total Environment 568: 507-511.
30. Massos A, Turner A (2017) Cadmium, lead and bromine in beached microplastics. Environ Pollut 227: 139-145.
31. McDevitt JP, Criddle CS, Morse M, Hale RC, Bott CB, et al. (2017) Addressing the Issue of Microplastics in the Wake of the Microbead-Free Waters Act-A New Standard Can Facilitate Improved Policy. Environ Sci Technol 51: 6611-6617.
32. Mintenig SM, Int-Veen I, Löder MGJ, Primpke S, Gerdts G (2017). Identification of microplastic in effluents of waste water treatment plants using focal plane array-based micro-Fourier-transform infrared imaging. Wat Res 108: 365–372.
33. von Moos N, Burkhardt-Holm P, Köhler A (2012). Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure. Environ Sci Technol 46: 11327–11335.
34. Mor R, Sivan A (2008) Biofilm formation and partial biodegradation of polystyrene by the actinomycete Rhodococcus ruber. Biodegradation 19: 851–858.
35. Munno K, Helm PA, Jackson DA, Rochman C, Sims A (2018) Impacts of temperature and selected chemical digestion methods on microplastic particles. Environ Toxicol Chem 37: 91-98.
36. Nimchua T, Eveleigh DE, Sangwatanaroj U, Punnapayak H. (2008). Screening of tropical fungi producing polyethylene terephthalate-hydrolyzing enzyme for fabric modification. J Ind Microbiol Biotechnol 35: 843–850.
37. Arthur C, Baker J, Bamford H, (Eds.) (2009) Proceedings of the international research workshop on the occurrence, effects and fate of microplastic marine debris, Sept 9-11, 2008. NOAA Technical Memorandum NOS-OR&R-30: 530.
38. Nuelle M, Dekiff JH, Remy D, Fries E (2014) A new analytical approach for monitoring microplastics in marine sediments. Environ Pollut 184: 161-169.
39. Paço A, Duarte K, da Costa JP, Santos PSM, Pereira R, et al. (2017) Biodegradation of polyethylene microplastics by the marine fungus Zalerion maritimum. Sci Total Environ 586: 10-15.
40. Pirc U, Vidmar M, Mozer A, Kržan A (2016) Emissions of microplastic fibers from microfiber fleece during domestic washing. Environ Sci Pollut Res Int 23: 22206-22211.
41. Pramila R, Ramesh K (2011). Biodegradation of low density polyethylene (LDPE) by fungi isolated from marine water a SEM analysis. African J Microbiol 5: 5013-5018.
42. Russell JR, Huang J, Anand P, Kucera K, Sandoval AG, et al. (2011). Biodegradation of polyester polyurethane by endophytic fungi. Appl Environ Microbiol 77: 6076-6084.
43. Sanchez W, Bender C, Porcher JM (2014). Wild gudgeons (Gobio gobio) from French rivers are contaminated by microplastics: Preliminary study and first evidence. Environ Res 128: 98-100.
44. Schirinzi GF, Pérez-Pomeda I, Sanchís J, Rossini C, Farré M, et al. (2017) Cytotoxic effects of commonly used nanomaterials and microplastics on cerebral and epithelial human cells. Environ Res 159: 579-587.
45. Schoof RA, DeNike J (2017) Microplastics in the context of regulation of commercial shellfish aquaculture operations. Integr Environ Assess Manag 13: 522-527.
46. Seo HS, Um HJ, Min J, Rhee SK, Cho TJ, et al. (2007) Pseudozyma jejuensis sp. nov., a novel cutinolytic ustilaginomycetous yeast species that is able to degrade plastic waste. FEMS Yeast Res 7:1035–1045.
47. Shah AA, Hasan F, Hameed A, Ahmed S 2008. Biological degradation of plastics: A comprehensive review. Bio-technol Adv 26: 246-265.
48. Shim WJ, Song YK, Hong SH, Jang M (2016) Identification and quantification of microplastics using Nile Red staining. Mar Pollut Bull 113: 469-476.
49. Sivan A (2011). New perspectives in plastic biodegradation. Curr Opin Biotechnol 22: 422-426.
50. Sjollema SB, Redondo-Hasselerharm P, Leslie HA, Kraak MH, Vethaak AD (2016) Do plastic particles affect microalgal photosynthesis and growth? Aquat Toxicol 170: 259-261.
51. Skoog DA, Holler FJ, Crouch SR (2007) Principles of Instrumental Analysis (6th Ed.). Thomson Brooks/Cole, Belmont CA, 1039.
52. Sudhakar M, Doble M, Murthy PS, Venkatesan R (2008) Marine microbe-mediatedbiodegradation of low- and high-density poly-ethylenes. Int Biodet Biodegr 61: 203-213.
53. Sudhakar M, Trishul A, Doble M, Kumar KS, Jahan SS, et al. (2007). Biofouling and bio-degradation of polyolefins in ocean waters. Polym Degrad Stabil 92: 1743-1752.
54. Sujathan S, Kniggendorf AK, Kumar A, Roth B, Rosenwinkel KH, et al. (2017) Heat and Bleach: A Cost-Efficient Method for Extracting Microplastics from Return Activated Sludge. Arch Environ Contam Toxicol 73: 641-648.
55. Sussarellu R, Suquet M, Thomas Y, Lambert C, Fabioux C, et al (2016). Oyster reproduction is affected by exposure to polystyrene microplastics. Proc Natl Acad Sci USA 113: 2430–2435.
56. Talvitie J, Mikola A, Koistinen A, Setälä O (2017) Solutions to microplastic pollution – Removal of microplastics from wastewater

effluent with advanced wastewater treatment technologies. J Wat Res 123: 401-407.

57. van Sebille E, Wilcox C, Lebreton L, Maximenko N, Hardesty BD, et al. (2015) A global inventory of small floating plastic debris. Environ Res Lett 10.
58. Viršek MK, Lovšin MN, Koren Š, Kržan A, Peterlin M (2017) Microplastics as a vector for the transport of the bacterial fish pathogen species Aeromonas salmonicida. Mar Pollut Bull 125: 301-309.
59. Wang W, Wang J (2018) Different partition of polycyclic aromatic hydrocarbon on environmental particulates in freshwater: Microplastics in comparison to natural sediment. Ecotoxicol Environ Saf 147: 648-655.
60. Xu XY, Lee WT, Chan AKY, Lo HS, Shin PKS, et al. (2017) Microplastic ingestion reduces energy intake in the clam Atactodea striata. Mar Pollut Bull 124 798-802.
61. Yoshida S, Hiraga K, Takehana T, Taniguchi I, Yamaji H (2016) A bacterium that degrades and assimilates poly (ethylene terephthalate). Science 351: 1196-99.
62. Song YK, Hong SH, Jang M, Han GM, Jung SW, et al. (2017) Combined effects of UV exposure duration and mechanical abrasion on microplastic fragmentation by Polymer Type. Environ Sci Technol 51: 4368-76.
63. Zhao S, Zhu L, Wang L, Li D (2014) Suspended microplastics in the surface water of the Yangtze estuary system, China: first observations on occurrence, distribution. Mar Pollut Bull 86: 562-68.
64. Zhang W, Zhang S, Wang J, Wang Y, Mu J, et al. (2017) Microplastic pollution in the surface waters of the Bohai Sea, China. Environmental Pollut 231: 541-548.
65. Ziajahromi S, Neale PA, Rintoul L, Leusch FDL (2017) Wastewater treatment plants as a pathway for microplastics: Development of a new approach to sample wastewater-based microplastics. Water Research 112: 93-99.