VOLUME 10 ISSUE 1 2024

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 10, No. 1, 364-382 (2024)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Microplastics and its Impacts on Marine Environment and Biotic Communities – A Global Perspective

Deborah Anne Rose N.[1], Rebecca Cathrine Jayakumari D.[1], Sheeba Anitha Nesakumari C.[2], Mahesh T.C.[3], Saravanan R.[1] and Thirunavukkarasu N.[1*]

[1]Department of Zoology, Dr. Ambedkar Government Arts College (Autonomous), Vyasarpadi, Chennai, India
[2]Department of Zoology, Madras Christian College (Autonomous), Tambaram, Chennai, India
[3]Department of Zoology, Vivekananda College, Agasteeswaram, Tamil Nadu, India

**Corresponding Author*

Received: 21st November, 2023; **Accepted:** 29th December, 2023; **Published online:** 7th March, 2024

https://doi.org/10.33745/ijzi.2024.v10i01.041

Abstract: A global issue that is prevalent nowadays and has become a hot topic is pollution caused by microplastics. They are dominating the entire earth including all ecosystems and pristine environments. Bioaccumulation of microplastics occurs in sediments, water columns and living organisms. In this review, studies based on microplastics research, conducted on seven continents, all over the world, were reviewed and discussed. The abundance of microplastics differs in each country based on different factors such as population, urbanization etc. The review focusses on both physical parameters (color, shape and size) as well as chemical parameters (composition) of microplastics. Impacts of microplastics on diverse groups of marine life was documented. Recent advances in technology for detection of microplastics were compared among different continents. Wide span of research on microplastics is needed in countries which are yet to be explored. Hence, future studies need to aim at developing standardized techniques for detection as well as quantification of microplastics.

Keywords: Microplastics, Sediment, Water, Living organisms, Impact, Recent technology

Citation: Deborah Anne Rose N., Rebecca Cathrine Jayakumari D., Sheeba Anitha Nesakumari C., Mahesh T.C., Saravanan R. and Thirunavukkarasu N.: Microplastics and its impacts on marine environment and biotic communities – A global perspective. Intern. J. Zool. Invest. 10(1): 364-382, 2024.

https://doi.org/10.33745/ijzi.2024.v10i01.041

Introduction

The current environmental issue that has been arising globally is plastic pollution. Plastics have pioneered their way into the earth during the 19th century, in the form of Bakelite (a chemical combination of formaldehyde and phenol), discovered by Leo Baekeland, a Belgian chemist. Around 400 million tons of plastic waste has been generated each year (Lampitt *et al.*, 2023).The main issue arises during its disposal and degradation step. The chemical nature of plastics makes it arduous for the process of degradation.

The plastics tend to break down into smaller particles called microplastics of size smaller than 5 mm in diameter (Rochman *et al.*, 2019). Contamination caused by microplastics was first recorded in the year 1972 by accumulation in water bodies (Carpenter and Smith, 1972). Extensive research on microplastics was ventured during the 20th century due to its detrimental impacts on the environment.

Microplastics are classified into two main categories, they are primary microplastics and secondary microplastics (Auta *et al.*, 2017). Primary microplastics are manufactured small sized plastics whereas secondary microplastics are formed from the fragments of larger plastic items (GESAMP, 2016). The sources of primary microplastics include microbeads used in cosmetic industry, resin beads for industrial purposes (Julienne *et al.*, 2019). Microplastics vary in size, shape, color and composition. Till date, microplastics has been identified in fresh water ecosystem, marine ecosystem, mangroves, desert regions, living organisms, air, snow and food (Curren *et al.*, 2021).

Extensive research has been carried on detecting microplastics in water column (Dahmes *et al.*, 2020), sediment (Kiss *et al.*, 2021) and bioaccumulation in living organisms (Collard *et al.*, 2017) along with its negative impacts on the environment. So far, microplastics were detected in diverse species of fishes, oysters, clams, mussels, scallops, shrimps (Baechler *et al.*, 2019), snails (Leinsschmidt, 2021), corals (Hall *et al.*, 2015), green sea turtle (Carson *et al.*, 2018) and krills (Wenbin *et al.*, 2023). Simply because of their appearance and size, microplastics are mistaken as food by living organisms.

Microplastics act as substrate for colonization of microorganisms. This results in increase of the plastic's density. Hence, microplastics will sink to the bottom making it more vulnerable for the biota to consume it (Wright *et al.*, 2013). Different microorganisms that colonize microplastics were found to be bacteria and fungi. Bacteria such as *Aeromonas*, *Rhodococcus*, *Pseudomonas*, *Enterobacter*, *Halomonas*, *Mycobacterium*, *Photobacterium*, *Shigella* and fungi were identified in microplastic samples (Yang *et al.*, 2023). Most of them belong to the harmful category of microbes.

Therefore, microplastics have gained a worldwide dominion over the ages. Hence, the main objective of this review was to summarize the current state of knowledge on microplastic research of the seven continents globally. The latest technologies and equipments used in different countries to detect microplastics were emphasized. The fate and toxicity of microplastics on aquatic life was accentuated and the safe methods for remediation of microplastics were highlighted.

The following phrases were used in order to retrieve information from different sources. It includes microplastic accumulation in different countries, contamination of microplastics in sediments, water bodies and different living organisms. Microplastic contamination in different ecosystems such as marine, freshwater, desert and mangroves were included. The physical and chemical nature of microplastics were documented and put in the form of a tabulation. The significance of each and every study, new ideas introduced by the author and further future goals were also documented.

Accumulation of microplastics:

Tons of microplastics have been identified in water bodies, sediments and biota. The concentration tends to differ among the three depending on the different sources which contribute to the deposition.

Accumulation of microplastics in sediments:

Many studies all across the globe, have been conducted to detect the presence of microplastics in sediments. The abundance of microplastics in freshwater ecosystem of Asia was about 30000 items Kg^{-1}dry wt of the sample. China had the highest concentration of microplastics in sediments of marine ecosystem (Phuong *et al.*, 2022). In America, the concentration was 28000 part Kg^{-1} dry weight of the sediment (Ballant *et al.*, 2016) and up to 688.99±3308 particles m^{-3} in Africa (Nell and Froneman., 2015). European countries also showed an increase in value upto 3177± 1970 items/Kg (Kiss *et al.*, 2021), followed by Australia with 0.18 to 129.2 mg Kg^{-1} (Beibei *et al.*, 2019) and Antarctica with the least concentration of less than 5 particles/10 m^{-1} (Reed *et al.*, 2019).

Accumulation of microplastics in water:

The current data recorded showed 0.004 items/m^3 of microplastics in freshwater ecosystem (Phuong *et al.*, 2022) and about 0.1 to 27840 items m^{-3} in marine environment of Asia. The accumulation of microplastics in other continents include America with 1277 – 12645 particles Km^{-2} (Baechler *et al.*, 2019), Africa with 257.9±53.36 and 1215±276.7 particles m^{-3} (Nel and Froneman, 2015). This was followed by Europe with 1.14 parts/m^3 at White Sea basin and Arctic Sea had 5 to 66 particles/mg wet weight of the sample (Bergmann *et al.*, 2023). Ground water aquifers in Australia had 89±55 micrometer (Subharthe *et al.*, 2021). Antarctica showed traces of contamination with 117 particles/L (Catherine *et al.*, 2017).

Accumulation of microplastics in living organisms:

Microplastics were detected in various organisms, from the largest marine fishes to the smallest microorganisms. They were found in the gastrointestinal tract, gills and internal organs of diverse living organisms. It consist of plankton with accumulation of 164 particles/m^3 (Pazos *et al.*, 2018), corals consist of 50 µg plastic $cm^{-1}h^{-1}$ (Hall *et al.*, 2015), marine fishes had 112 pieces of microplastics on an average (Alfred *et al.*, 2022), mangrove fishes were found to have 0.79 to 1.00 particles (Naidoo *et al.*, 2020), mussels had 1013 pieces due to its filter feeding nature (Burglund *et al.*, 2019). Even reptiles had 81 pieces of microplastics in their gut (Mackenzie and Varvara., 2021). Endangered species such as green turtles had 7 pieces of microplastics stuck in the gastrointestinal tract (Carson *et al.*, 2018). Recent research has been focused on the bioaccumulation and fate of microplastics inside the body of living organisms. The microplastics accumulation studies from various continents and living organisms depicted in Figures 1 and 2. An international status on microplastics in marine environment and biotic communities is given in Table 1.

Factors Fate and Impacts of microplastics:

Several factors play a vital role in the impact of microplastics on the environment. They have been listed below:

Colour:

A variety of different colours has been documented throughout all continents such as blue, green, red, yellow (Esther *et al.*, 2018), white, brown, black and transparent, blue and grey (Ramirez *et al.*, 2021). Researches had been conducted in order to demonstrate the impact of colour present in microplastics on living organisms. Experiments were conducted on fishes to find out the colour preference. Fishes were attracted to a wide range of colors like red, yellow and green. Microplastics with these colours were consumed at a faster rate (Okomoto *et al.*, 2022). They were perceived as food particles by the fishes. The least preferred colours were grey and blue. This resulted in the accumulation of microplastics in the gastrointestinal tract.

Shape and Size:

The different shapes of microplastics noted were fibre, fragment, pellet, foam and film, with fibre in the lead (Tata *et al.*, 2020). The fibre uptake may have come from fishing nets, ropes, textile industries etc. The shape can provide a clue on the various sources of microplastics hindering the marine life (Koongolla *et al.*, 2022). The different size ranges of microplastics was regarded as prey by the pradator, hence resulting in the feeding behaviour. Sometimes odour of prey fishes is similar to the odour of microplastics due to the additives thereby leading to consumption. Other factors include temperature (Manjon *et al.*, 2022)

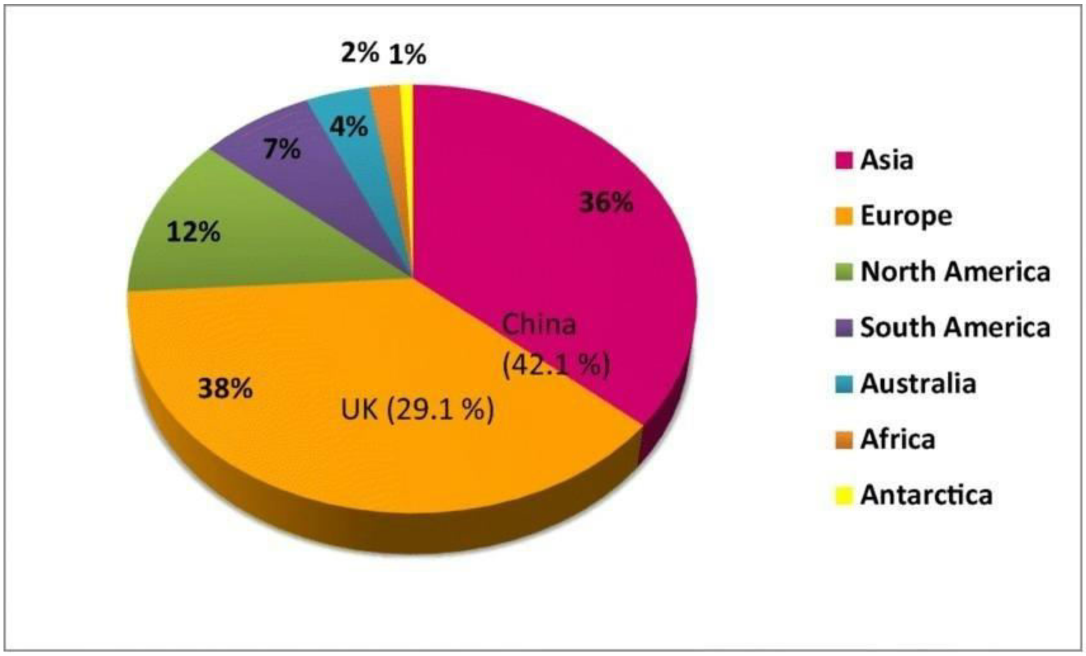

Fig. 1: Percentage of Microplastics in each continent.

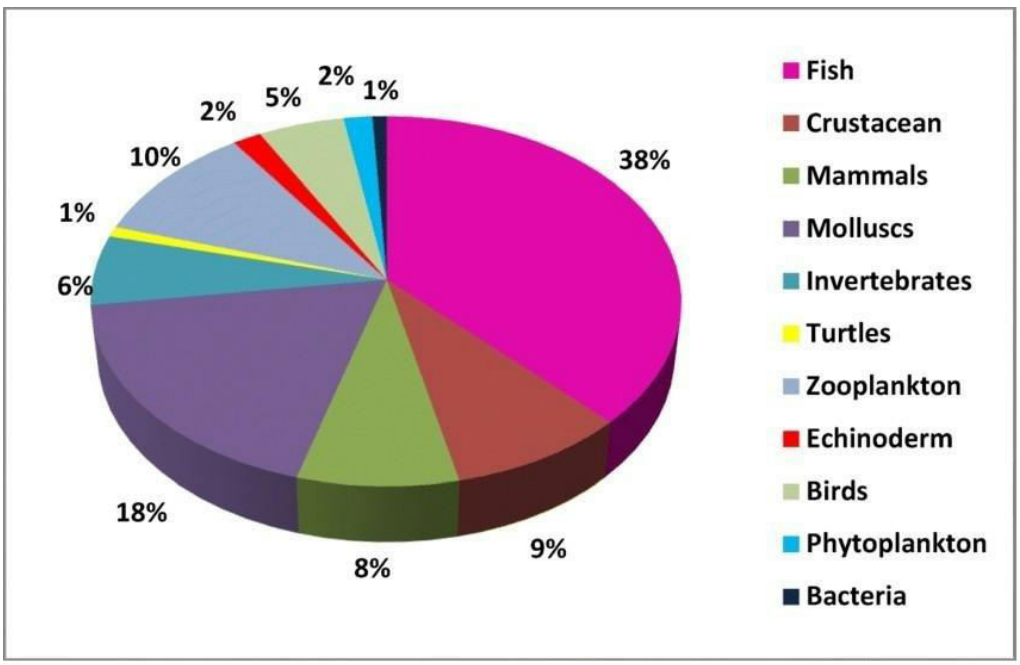

Fig. 2: Impact of microplastics on different living organisms. Courtesy: Ajith *et al.*, (2020)

Table. 1: Microplastics in marine environment and biotic communities an international perspective

(A) Asia

S.No..	Author and Year	Nature of work	Place	Method	Significance	Result	Nature of microplastics
1	Phuong *et al.* 2021	Water sediment	Asia		Asia is considered as the hotspot for plastic production	Water –0.004 item/m^3 Sediment-30000 items Kg^{-1} drywt	Polyethylene Polypropylene
2	Gabisa *et al.* 2022	Fiddler crab, *Mytilus edulis*	South East Asia	ATR-FTIR	Microplastic exposure leads to haemocyte mortality	Microfibres adherence to soft tissue Size-150micrometer	LDPE. HPDE, PP, PB, PET, PVC
3	Wang *et al.* 2021	Water Sediment Biota	Yellow sea, China	Density separation FTIR	Analysed with 176 sampling sites	Water-0.1 to 27840 items m^{-3} Sediments-13 to 14712 items Kg^{-1}dw	TYPE - PE. PET Shape - Fibre, fragment, filament
4	Liu *et al.* 2021	*Mytilus edulis*	Dalian region, China	KOH digestion SEM analysis TGA-FTIR-GC/MS	KOH does not affect color of microplastics Recovery rate was 97.3%	Abundance-0.58 mg/kg of sample	Type - PE, PVC, PP, PS
5	Jabeen *et al.* 2017	*Hyporhamphus intermedius*	Yellow sea, China	Floatation-NaCl Filtration-5micron	30% of H2O2 increased efficiency of extraction	Abundance-0.2 to 3.0 items/individual Filefish highest microplastic accumulation - 7.2 items/individual	Shape- Fibre Color-Transparent
6	Wang *et al.* 2023	Water from clouds	Mount Fuji, Japan	Condensa-tion with sea spray	First detection of microplastics in clouds	70 microplastic samples observed average concentration- 6.7 to 13.9 particles/litre	Size - 6.1 to 94.6 microplastics/micrometer
7	Kataoka *et al.* 2019	Water	36 sites from 29 rivers of Japan	GESAMP	Water parameters correlated with microplastics	31 sites consist of microplastics	
8	Yagi *et al.* 2022	Fishes	Japan	FTIR	Commercially important fishes targeted	Highest found in *Scomber japonicus*-62.5%	Type - PE Shape - film

9	Park *et al.* 2020	Fish and Water	Han River, South Korea	FTIR	Abundance of microplastics is influenced by depth	Water- 2m depth- 20 to 18 part/m^3 Fish - 1 to 16 particles/fish	Type - PE, Silicon, PTFE, PE, PET Shape - Fragment
10	Wang *et al.* 2021	Sediment	Badain Jarden desert from Central Asia	Micro-FTIR	Black trajectory method was used	Size - 50 to 200 micrometer	Type PET-25% Phenoxy resin-25% Polyamide-9% Epoxy resin- 28%
11	*Tang et al. 2023*	Dry sediment	Taul river from Central and East Asia	Visual examination	First work in desert region	Abundance in sediment- 15 to 46 items/kg	
12	Sin *et al.* 2023	Water	South Asia	FTIR	Review about microplastics in all water bodies done	Size – less than 1000 micrometer	Type - PE, PP, PET, PSLDPE, HDPE, PVC Shape - Fibre, fragment, foam, pellet, film
13	van der Hal *et al.* 2017	Water	Meditteranean Sea	Density separation	First work on oligotrophic waters	Mean abundance of microplastics - 7.68 particles/m^3	Color White, transparent Shape- fragments
14	Ali *et al.* 2023	Sediment	beaches	Density separation	Work done in high as well as low tide	Low tide – 5.5 to 21.2 particles/kg, High tide- 6.3 to 16.5 particle /kg	Color - Transparent, blue Type - PE, HDPE Shape - Fragment, filament
15	Piyawardhana *et al.* 2021	Dry fishes	Taiwan Japan India China Thailand	Micro Raman spectroscopy	Work done on 14 different dry fishes	*Etrumeus micropus* had the maximum of microplastic accumulation	Type - PET, PE, PVC,PP Shape - Fibre

(B) North America

16.	Baechler *et al.* 2020	Sediment, Water Finfish-4 Bivalve-5 Oyster-1 Clam-1 Mussel-1	Lawren river North shore channel San Gabriel river	FTIR Raman spectroscopy	Work on additives as well as monomers Microplastics detected in human faeces	Microplastics found in municipal waste =0.05 ± 0.0024 particle L-1 Microplastics in water = 1277 - 12645 particles Km-2	Type - HDPE, LDPE, PEET, PETE, nylon, PP, PMMA Shape - Fibres, films, fragments, Foams Additives - Bisphenol, phthalates, organotoxins

17.	Anderson *et al.* 2016	Sediment Water Marine fishes	Freshwater bodies of Canada	Density separation	Fate and factors of microplastics are explained thoroughly	Sources, types and distribution of microplastics were documented	Type - LDPE – PP, PE, HDPE-Polyamide,PVC, Polystyrene
18.	Gies *et al.* 2018	Primary and secondary effluent Primary and secondary sludge	Waste water-Vancouver	FTIR	Microplastics found in waste water was detected	Abundance of microplastics found was 1.76±0.31 trillion particles 0.03±0.01 trillion released in the environment	Type - PS, Polyester, Nylon, PP, Cellulose Shape - Fibre, fragment, pellet, foam, Color - Blue, green, red, yellow
19.	Ballent *et al.* 2016	Sediment	Lake Ontaro, Canada	Raman spectroscopy	Distribution pattern of microplastics near shore	Abundance of microplastics = 28000 part/Kg dry sediment	Type LDPE, HDPE Shape - Fibre, fragments
20.	Kleinschmidt & Janosik 2021	Red mouth rock snail Crown conch snail	Gulf of Mexico	Acid digestion Filtation –0.45 micrometer Microscopic analysis	Factors which result in accumulation of microplastics	Total of 256 microplastics detected in the tissues	Shape Microfibre- 97%, Microfilament-3%
21.	Bikker *et al.* 2020	Water	Chesapeake Bay	FTIR	Correlation with land use and population density was done	Highest concentration of microplastics 1.245 particles/m 3	Type - PE, PP, Fragment, Film, fibre
22.	Alvarez-Zeferino *et al.* 2020	Sediment	Gulf of Mexico	Seiving-1.13mm FTIR	Sediments from 5 sandy beaches was examined Gulf of California had the highest abundance of microplastics	Abundance - 31.7 to 545.8 microplastics/m2 Maximum quantity of microplastics seen in high tides	Type - PP, PE, PS Shape - Pellet, microfiber, fragment, foam Color - Blue, black, red, green, white
23.	Toner & Midway 2021	Freshwater fishes- 7 species	Museum samples from U.S.A	FTIR	Fish samples from 1997 upto 2006 was analyzed	Total of 3 microplastic pieces of size 0.5mm to 4mm were found	Type - PP, PE Shape- fibres Color - Black, blue
24.	Borges- Ramírez *et al.* 2020	Pelagic and demersal fishes	Campeche Bay	FTIR	A comparative- Study on the accumulation of microplastics between pelagic and demersal species was done	Abundance of microplastics Demersal fishes- 1.42± 0.4 gcm^{-3} Pelagic fishes-1.04± 0.24 gcm^{-3} 316 pieces of microplastics	Type - PTFE film, polyamide, PE, PVC Shape - Fibre, fragment, pellet Color - White, brown, black, green, blue, orange, brown,

						isolated from 240 individuals	yellow, red
25.	Borges-Ramírez *et al.* 2021	Black vulture	Campeche, Mexico	FTIR	First study of contamination of microplastics in the pellets of avian raptors	225 particles of microplastics was detected (15.582± 17.47 µg.g^{-1}) Compunds such as Cd,Pb,Cu,Cr,Hg was identified	Type - PE, Polyamide Shape - Film, fragment, fibre Color - Black, white

(C) South America

26.	*Arias et al. 2019*	*Micropogonias furnieri*	Bahía Blanca Estuary, Argentina	Stereo microspcopic analysis	First proof of the contamination of fishes from the Atlantic sea	241 pieces of microplastics were isolated	Shape - Fibre, fragment, pellet, laminas
27.	Moreschi *et al.* 2020	*Anodotites trapesialis* (duck mussel)	Brazil-laboratory	Raman spectroscopy	Microplastics assimilation in the tissues, pseudofaeces, faeces	Microplastics of size 55-110µm was detected	Type - PE
28.	Pazos *et al.* 2018	Water contains phtoplankton and zooplankton	Rio del la plata estuary	stereomicroscope	Zooplankton accumulated more microplastics than phytoplankton	Mean density of microplastics Zooplankton - 164 particles/m^3 Phytoplankton - 114 particles/m^3	Shape-fibre Color-blue
29.	de Faria *et al.* 2021	Water	Pantanal-grassland	Filtration-0.45µm,47µm steromicroscopy	Microplastics was found to be lower in panatanal than tributaries	Microplastics in pantanal-4.5± 2.5.100l^{-1} Microplastics in tributaries-19.9± .6.100l^{-1}	Shape - Fibre, fragment, pellet
30.	Montecinos *et al.* 2022	Water	Tandil	FTIR	Contribution of urban sewage to microplastic pollution was studied	Concentration of microplastics-72000 microplastics/litre	Type-PE Size - 100 µm -1.5 µm Shape - Fibre
31.	Alfred *et al.* 2022	Marine fishes	Guyana	Microscopy	Accumulation of microplastics in marine fishes was found	112 pieces of microplastics was detected 40% of fishes had microplastics	Shape - Pellets, microbeads, fragments, fibre, film, foam Color-white

32.	Mackenzie & Vladimirov 2023	Herpeto-fauna	Paraguay	Faecal analysis	Water sources did not have effect on microplastics detection	81 pieces of microplastics were found	
33.	Staichak *et al.* 2021	Freshwater bivalves	Brazil	Faecal examination	Bivalves serve as bioindicators of microplastic pollution	Microplastics was detected in soft tissues, faeces and Pseudofaeces	Shape Pellet,microfiber Color Transparent, blue, green
34.	Alves *et al.* 2022	Sediment	Patos mirim system	Radiocarbon dating	Vertical distribution of microplastics in six sediment cores was examined	Basal region had zero microplastics whereas the upper layer had microplastics	Type - Rayon, PVC, acrylate, polycarbonate Shape - Fibre, fragment
35.	Kutralam-Muniasamy *et al.* 2020	Sediment, Water, Fishes, Bivalves	Latin America	FTIR Raman spectroscopy	Latin America contributes 4% of total plastic production	8% dumping of plastics	Type - PE, PP, terephthalate

(D) Africa

36.	Akindele *et al.* 2019	Gastropo-ds	Osun river	FTIR	First emprical account of West Africa	Dection of microplastics	Type - PE Shape - Fibre
37.	Sparks and Immelman 2020	Marine fishes	Agulhas Bank	Microscopic analysis	First publication in offshore fish from South Africa	87% of fishes had microplastics	Shape - Fibres Color - Black
38.	Nel and Froneman 2015	Water Sediment	Beaches	Density separation	Bays had more plastic accumulation than open seas	Beach sediment- 688.9±3308 ±1449 particles m^{-3} Water column -257.9±53.36 and 1215±276.7 particles m^{-3}	Shape - Fibre Color - Black, Blue
39.	Dahms *et al.* 2020	Water Sediment Chironomous larvae	Braamfontein spruit	Seiving-4000,215,53 µm Density separation	When there is increase in depth but decrease in flow of the water body, then microplastics will settle at a faster rate	Water – 705 m^{-3} Sediment - 166.8 particles Kg^{-1} chironomous larva- 53.4 particlesg^{-1}	

40.	Naidoo *et al.* 2020	Magrove fishes	Mangroves - Kwazulu	Proteinase-k digestion method FTIR	Highest rate of microplastics were found in juvenile fishes	Abundance of microplastics in fishes- 0.79 1.00 particles/fish	Type - PE, PVC, Rayon, Nylon Shape - Fibre, Fragment Colour - Blue
41.	Boshoff *et al.* 2022	Seagrass	Kynsna estuary	Extraction using $ZnCl_2$ floatation Sediment microplastics isolation unit	Seagrass has the ability to trap microplastics	Total of 1083 particles of microplastics were identified	Shape – Fibre, Fragment
42.	Preston-Whyte *et al.* 2021	Water Sediment	Port of Durban	Static immersable water pump particle filtration system	Analysis of water and sediments that overflow from storm water drains into the river	Abundance of microplastics in water- 99.14± 36.29 particles.m^{-3} Abundance of microplastics in sediment- 2400± 529 particles Kg^{-1}	Type – PP, PET, PE, Polystyrene
43.	Naidoo & Glassom 2019	Water	Coastal shelf- Natal	Mantra trawl -333 µm Microscopic analysis	Plastic concentration was higher in winter when compared to summer due to the wind and current	Abundance of plastics during summer- 2.96 particles/100m^2 Abundance of plastics during winter- 5.54± 3.26 particles/100m^2	Shape - Fragment,Film, Fibres Color -White, Opaque, Blue, Black
44.	Tata *et al.* 2020	Sediment	Gulf of Annaba	Density separation FTIR	Tidal flow patterns played an important role in the accumulation of microplastics	Abundance of microplastics in sediment- 182.66± 27.32 Kg^{-1}	Type - PE, PP, PT, PS Shape - Fibres, fragments, pellet, film, foam
45.	Baker *et al.* 2020	Pelagic fishes	South Africa	FTIR	Native fishes of South Africa were analyzed	813 pieces of microplastics were detected	Type – PE (20%), Polyester (20%) PP (7%) Proplylene : Diene (33%) Shape - Fibres, fragments

(E) Europe

46.	Kiss *et al.* 2021	Sediment	Tisza River-Hungary	Density separation	Georaphical and environmental factors that influence the deposition of microplastics has been studied	Abundance of microplastics in sediment- 3177± 1970 items/Kg	Shape - Fibre, fragment, pellet Color - Red, blue, green, colorless
47.	Collard *et al.* 2017	Europian anchovy	Mediterranean Sea	Raman spectroscopy	Translocation of microplatics in the liver has been identified	80% of anchovies contain microplastics	Type - Polyethylene, styrene and acrylonitrile
48.	Giani *et al.* 2019	Demersal fishes	Meditteranean sea	FTIR	Bioindicator species were slected for microplastic detection	Highest percentage of microplastics was found in European Hake – 48%	Shape - Fibre, sheeet, sphere, fragment
49.	Menéndez-Manjón *et al.* 2022	Sludge and effluent (primary, secondary)	Waste water treatment plants	FTIR	Connection between temperature and microplastics accumulation was achieved	Removal efficiency was proved to be 89%	Type - PE, PP, PET, PA Shape - Fragments, fibres
50.	Berglund *et al.* 2019	Duck mussel	Hoje river	Full body digestion with HNO3	Number of microplastics increases with mussel size	Total of 1013 pieces of microplastics were identified	Shape - Fibres
51.	**Barboza *et al.* 2017**	Sea bass	Laboratory	Spectrofluorometry	Mercury accumulation increases with microplastic concentration in fishes	Effects of microplastic accumulation AChe inhibition Lipid oxidation increases in brain and muscle accumulation of mercury in the brain and muscle	
52.	Esiukova 2017	Sediment	Baltic sea	Random sampling	Upper sediments of 2cm was used	Microplastic accumulation- 1.3 to 36.3 items/Kg of dry sediment	Shape - Foam Type - Paraffin
53.	Zobkov & Esiukova 2017	Sediment	Baltic sea	Density separation	Calcite fraction digestion method was used and it was	Microplastic extraction efficiency- 92%	Shape - Film, fragmnet

					first carried out practically	Concentration of microplastics 34± 10 items/Kg DW	
54.	Ershova *et al.* 2021	Water	White sea basin	Monitoring protocol	200 volunteers were trained to detect microplastics in water	Microplastic concenttration- 1.14 part/m3	Type - PE, PET, PVC
55.	Bergmann *et al.* 2023	Algae	Arctic sea	Raman analysis	Effects of microplastics on benthic food webs was studied	Abundance of microplastics- 5 to 66 particles/mg wet weight	Type - PE, PET, PP, PS, PVS, PU, PVA, Nylon, PLS, SBT, SAN, PLA, CE

(F) Australia

56.	He *et al.* 2019	Sediment	Brisbane river	Density separation FTIR	Relation between microplastic abundance and flow velocited was established	Abundance of microplastics - 0.18 to 129.2 mgKg-1	Type - PE, PP, PA, PET Size- less than 3mm Colour - Coloured microbeads
57.	Samandra *et al.* 2021	Water	Bacchus marsh	LDIR- Laser Direct Infra Red Imaging System	Unique study of groundwater aquifers	Average size of microplastics- 89± 55 µm	Type -PE, PP, PVC, PET, PA, PMMA
58.	Su *et al.* 2019	Marine fishes	Wetland	FTIR	*Gambusia holbrooki* (indicator)	Abundance of microplastics - 0.11 items/individual Female fishes had more microplastics than male	Type - PE Shape - Fibre
59.	Wootton *et al.* 2021	Marine fishes	Suva Fiji Brisbane Sydney	FTIR	Fishes in Australia had more microplastics than fishes in Fiji	Microplastics in Australia- 61.6% Microplastics in Fiji- 35.3%	Type - Polyolefin Shape - Fibre, film
60.	Yick & Travers 2022	Bluefin Tuna	Tasmania	Microscopic analysis	Large size plastics were extracted	Macroplastics >20mm Megaplastics>100mm	Type - Food container, Drum lid, Bucket

61.	Wootton *et al.* 2021	Marine fishes	Victoria Tasmania Wales	FTIR	Plastic ingestion in fishes was less compared to other global studies	Average microplastics - 0.94 piece/fish	Type - Polester, nylon, cellaphane Shape - Fibre, fragment, film
62.	Bridson *et al.* 2020	Sediment	Auckland	Transect method Density separation FTIR	West coast beaches had more microplastics compared to East coast beaches	Microplastic abundance- 459 particles.m-2	Type - Cellulose, PE, PET Shape - Fibres, fragment, film
63.	Webb *et al.* 2021	Green lipped mussel	Laboratory	Biochemical assay kits	There was decrease in byssus production due to accumulation of triclosan and microplastics	There was a decrese in oxygen uptake High oxidative stress, high lipid peroxidation High SOD activity	
64.	Hall *et al.* 2015	Scleractinian corals	Great Barrier Reef	ATR-FTIR	First data recorded about the ingestion of microplastics by Scleractinian corals	Microplastics were found in the mesenterial tissue in the gut cavity Plastic abundance- 50 µg plastic $cm^{-2}h^{-1}$	
65.	Caron *et al.* 2018	Sea turtles	Great Barrier Reef	FTIR	The extraction protocol was validated globally	7 pieces of microplastics were found	Type - PE, PP, PVC Size - >100 µm

(G) Antarctica

66.	Waller *et al.* 2017	Water	Antarctica	Review	Ross sea gyres responsible for accumulation of microplastics	Mean value of microplastics in sea water-117 particles L^{-1}	
67.	Reed *et al.* 2018	Sediment	Rothera research station	FTIR	Lack of sewage treatment plant responsible for microplastic accumulation	Concentration of microplastics- <5 particles/$10ml^{-1}$	Shape - Fibre, sphere Color - White, red, green, turquoise, black, blue
68.	Zhu *et al.* 2023	Marine fishes	Weddell sea	FTIR	Fundamental data of microplastics accumulation in Antarctic fishes	Abundance of microplastics- 0.72 to 1.7 items/individual	Type - PP, PA, PE

69.	Garza *et al.* 2023	Water	Antarctic Peninsula	Micro- FTIR spectrometry	Increase in microplastics in 2020 compared to 2017	Samples from glaciers, fjords, surface water were analyzed	
70.	Mancuso *et al.* 2023	Emerald Rock cod	Terranova Bay	Raman spectroscopy	Clothing of research personal contributed to the microplastic accumulation	Microfibres were dominant	Type - PET, PP, PES, PU Color - Indigo
71.	Ergas *et al.* 2023	Antarctic fishes	Antarctica	Micro- FTIR	Microplastics detected in endemic species	358 microplastic pieces were identified	Type - PET Shape - Microfibre Color - Blue, black, red, green, violet
72.	Aves *et al.* 2022	Snow	Ross sea	Micro- FTIR	First work on snow	Microplastic abundance- 29 plastics L-1	Type - PET Shape- Fibre
73.	Zhang *et al.* 2023	Water	Antarctica	FTIR	Subsurface water had more microplastic accumulation than surface sea water	Abundance of microplastics in surface water 0.10 ± 0.14 items/m3 Abundance of microplastics in subsurface sea water 1.66 ± 1.20 items/m3	Type - PE, PP, Polyester
74.	González-Pleiter *et al.* 2020	Water	Byers Peninsula	FTIR	First freshwater analysis	Abundance of microplastics- 0.95 items/1000 m3	Type - Polyester, acrylics, polytetra fluoroethylene films Shape- Fibre Color- Black, red
75.	Zhu *et al.* 2023	Antarctic krill	Orkney island Shetland island	FTIR	Microplastic contamination in the food chain was analyzed	Mean abundance of microplastics- 0.29 0.12 items/individual	Type - PE, PP Shape- Fibre Color - Black, blue, red

and the flow rate of water (Kiss *et al.*, 2021). Increase in temperature resulted in higher retention of microplastics in water bodies. When the flow rate of the water decreased, there was increase in the settlement of microplastics.

Fate and impacts of microplastics on living organisms:

The microplastics consumed by living organisms e.g. fishes tend to get accumulated in the gastrointestinal tract. From there it passes through the intestinal barrier and end up in the liver affecting the biochemical process. The rest is excreted out of the body (Collard *et al.*, 2017).

Thus, there is a transfer of microplastics from lower to higher food chain level. Retention of microplastics in the gastrointestinal tract can cause intestinal obstruction, injury and lower food consumption (Jovanovic., 2017). The chemicals adsorbed by microplastics may be released, leading to its entry into the bloodstream. This resulted in neurotoxicity, oxidative damage and energy related changes in the body (Barboza *et al.*, 2017). Accumulation of microplastics in the gills lowered the respiratory efficiency causing hypoxia (Li *et al.*, 2021). Deposition of microplastics in tissues was also observed (Jovanovic., 2017). The fate of microplastics inside the body of the fish has not been clearly understood till now.

Extraction techniques:

The basic extraction of microplastics from biota was done using KOH in order to digest the organic matter completely. The recovery rate was proved to be 97.3% (Lui *et al.*, 2021).

Chemicals such as hydrogen peroxide was also used (Jabeen *et al.*, 2017), proteinase K was used for enzymatic digestion (Naidoo *et al.*, 2020). For extraction of microplastics from sediments and water, density separation technique was used and was proved to be really effective (Dahms *et al.*, 2020).

Instruments used for detection of microplastics:

- µ-FTIR was used to detect small sized microplastics from snow which was the recent advances in detection (Reeves., 2022).
- ATR-FTIR was used to detect microplastics in corals, fishes, crabs and living biota due to its high refraction rate (Hall *et al.*, 2015)
- LDIR (Laser Direct Infrared spectroscopy) was used to detect microplastics in groundwater aquifers (Samandra *et al.*, 2021)
- Raman spectroscopy was used to detect microplastics in bivalves (Moreschi *et al.*, 2020) Micro Raman spectroscopy was used to detect microplastics in dried fishes (Piyawardhana *et al.*, 2021).

Totally about 12 types of microplastic composition has been recorded. They are LDPE (Low Density Polyethylene), HDPE (High Density Polyethylene), PP (Propylene), PE (Polyethylene), PB (Polybutene), PVC (Plyvinyl chloride), PET (Polyethylene terephthalate), PMMA (Polymethyl methacrylate), PA (Polyamide), polystyrene, rayon and nylon (Samandra *et al.*, 2021).

Conclusion

Pollution caused by microplastics has become a global issue of the 20th century. The main reason was found to be anthropogenic disturbances in the freshwater as well as marine environment. Due to the increase in population over the years, there has been additional dumping of plastics into the waterbodies. Other factors include poor treatment of sewage, poor waste management, lack of recycling, industrial outlets near water bodies, geographical influences (wind, UV radiation from the sun, rainfall) and rapid urbanization. The presence of microplastics ranges from sediments present in water to the sediments of the Antarctic region, indicating that migration of microplastics occurs from one place to another. Consumption of marine organisms by humans, resulted in transfer of microplastics into the body. Recently, microplastics were detected in the bloodstream and faeces of humans. Hence, strict laws should be enforced in order to reduce the production of plastics. Every member of the society should take part in the awareness programs put forth by the

Government. Certain knowledge gaps have been identified in this review. Research should be focused on standardized methods for extraction of microplastics. Size and fractions should also be determined for comparative study. Fate of microplastics inside fishes should be analyzed further. New instruments are needed for easy detection of microplastics by layman. Last but not least, fields such as Ecology, Ecotoxicology, Environmental science subjects must be given importance in academics, as students will be the pillars of the future generation.

Acknowledgements

The authors are thankful to the authorities of Dr. Ambedkar Government Arts and Science College (Autonomous), Vyasarpadi, Chennai, India providing the necessary facilities.

References

Ajith N, Arumugam S, Parthasarathy S, Manupoori S and Janakiraman S. (2020) Global distribution of microplastics and its impact on marine environment-- a review. Environ Sci PollutRes. 27: 25970-25986.

Akindele EO, Ehlers SM and Koop JH. (2019) First empirical study of freshwater microplastics in West Africa using gastropods from Nigeria as bioindicators. Limnologica 78: 125708.

Alfred S, Ram M, Lakenarine R, Hemraj D and Maharaj G. (2022) Occurrence and characteristics of microdebris in commercial fish species of Guyana, South America. Mar Pollut Bull. 182: 114021.

Ali HJAS, Al-Thukair AA, Pulikkoden AK and Chanbash B. (2023) Microplastic Contaminants in the Sediment of the East Coast of Saudi Arabia. doi: 10.5772/intechopen.109019.

Alvarez-Zeferino JC, Ojeda-Benítez S, Cruz-Salas AA, Martínez-Salvador C and Vázquez- Morillas A. (2020) Microplastics in Mexican beaches. Resources Conservation Recycling 155: 104633.

Alves FL, Pinheiro LM, Bueno C, Agostini VO, Perez L, Fernandes EHL and García-Rodríguez F. (2023) The use of microplastics as a reliable chronological marker of the Anthropocene onset in Southeastern South America. Sci Total Environ. 857: 159633.

Anderson JC, Park BJ and Palace VP. (2016) Microplastics in aquatic environments: Implications for Canadian ecosystems. Environ Pollut. 218: 269-280.

Arias AH, Ronda AC, Oliva AL and Marcovecchio JE. (2019) Evidence of microplastic ingestion by fish from the Bahía Blanca estuary in Argentina, South America. Bull Environ Contam Toxicol. 102(6): 750-756.

Auta HS, Emenike CU and Fauziah SH. (2017) Distribution and importance of microplastics in the marine environment: a review of the sources, fate, effects and potential solutions. Environ Int. 102: 165-176.

Aves AR, Revell LE, Gaw S, Ruffell H, Schuddeboom A, Wotherspoon NE and McDonald AJ. (2022) First evidence of microplastics in Antarctic snow. Cryosphere 16(6): 2127-2145.

Baechler BR, Stienbarger CD, Horn DA, Joseph J, Taylor AR, Granek EF and Brander SM. (2020) Microplastic occurrence and effects in commercially harvested North American finfish and shellfish: current knowledge and future directions. Limnol Oceanog Letters 5(1): 113-136.

Bakir A, Van der Lingen CD, Preston-Whyte F, Bali A, Geja, Y, Barry J and Maes T. (2020) Microplastics in commercially important small pelagic fish species from South Africa. Front Mar Sci. 7: 574663.

Ballent A, Corcoran PL, Madden O, Helm PA and Longstaffe FJ. (2016) Sources and sinks of microplastics in Canadian Lake Ontario nearshore, tributary and beach sediments. Mar Pollut Bull. 110(1): 383-395.

Barboza LGA, Vieira LR, Branco V, Figueiredo N, Carvalho F, Carvalho C and Guilhermino (2018) Microplastics cause neurotoxicity, oxidative damage and energy-related changes and interact with the bioaccumulation of mercury in the European seabass, *Dicentrarchus labrax* (Linnaeus, 1758). Aquat Toxicol. 195: 49-57.

Berglund E, Fogelberg V, Nilsson PA and Hollander J. (2019) Microplastics in a freshwater mussel (*Anodonta anatina*) in Northern Europe. Sci Total Environ. 697: 134192.

Bergmann M, Allen S, Krumpen T and Allen D. (2023) High levels of microplastics in the Arctic Sea Ice Alga *Melosira arctica*, a vector to ice-associated and benthic food webs. Environ Sci Technol. 57(17): 6799-6807.

Bikker J, Lawson J, Wilson S and Rochman CM. (2020) Microplastics and other anthropogenic particles in the surface waters of the Chesapeake Bay. Mar Pollut Bull. 156: 111257.

Borges-Ramírez MM, Escalona-Segura G, Huerta-Lwanga E, Iñigo-Elias E and Rendón-von Osten J. (2021) Organochlorine pesticides, polycyclic aromatic hydrocarbons, metals and metalloids in microplastics found in regurgitated pellets of black vulture from Campeche, Mexico. Sci Total Environ. 801: 149674.

Borges-Ramírez MM, Mendoza-Franco EF, Escalona-Segura G and Rendón-von Osten J. (2020) Plastic density as a key factor in the presence of microplastic in the gastrointestinal tract of commercial fishes from Campeche Bay, Mexico. Environ Pollut. 267: 115659.

Boshoff BJ, Robinson TB and Von der Heyden S. (2023) The role of seagrass meadows in the accumulation of microplastics: Insights from a South African estuary. Mar Pollut Bull. 186: 114403.

Bridson JH, Patel M, Lewis A, Gaw S and Parker K. (2020) Microplastic contamination in Auckland (New Zealand) beach sediments. Mar Pollut Bull. 151: 110867.

Caron AG, Thomas CR, Berry KL, Motti CA, Ariel E and Brodie JE. (2018) Ingestion of microplastic debris by green sea turtles (*Chelonia mydas*) in the Great Barrier Reef: Validation of a sequential extraction protocol. Mar Pollut Bull. 127: 743-751.

Carpenter EJ and Smith KL. (1972) Plastics on the Sargasso Sea surface. Science 175(4027): 1240-1241.

Collard F, Gilbert B, Compère P, Eppe G, Das K, Jauniaux T and Parmentier E. (2017) Microplastics in livers of European anchovies (*Engraulis encrasicolus*, L.). Environ Pollut. 229: 1000-1005.

Curren E, Kuwahara VS, Yoshida T and Leong SCY. (2021) Marine microplastics in the ASEAN region: A review of the current state of knowledge. Environ Pollut. 288: 117776.

Dahms HT, Van Rensburg GJ and Greenfield R. (2020) The microplastic profile of an urban African stream. Sci Total Environ. 731: 138893.

de Faria E, Girard P, Nardes CS, Moreschi A, Christo SW, Junior ALF and Costa MF. (2021) Microplastics pollution in the South American Pantanal. Case Studies Chem Environ Engineer. 3: 100088.

Ergas M, Figueroa D, Paschke K, Urbina MA, Navarro JM and Vargas-Chacoff L. (2023) Cellulosic and microplastic fibers in the Antarctic fish *Harpagifer antarcticus* and Sub-Antarctic *Harpagifer bispinis*. Mar Pollut Bull. 194: 115380.

Ershova A, Makeeva I, Malgina E, Sobolev N and Smolokurov A. (2021) Combining citizen and conventional science for microplastics monitoring in the White Sea basin (Russian Arctic). Mar Pollut Bull. 173: 112955.

Esiukova E. (2017) Plastic pollution on the Baltic beaches of Kaliningrad region, Russia. Mar Pollut Bull. 114(2): 1072-1080.

Gabisa EW and Gheewala SH. (2022) Microplastics in ASEAN region countries: A review on current status and perspectives. Mar Pollut Bull. 184: 114118.

Garza TN, Barnes DK, Scourse JD, Whitaker JM and Janosik AM. (2023) Quantifying microplastics in fjords along the Western Antarctic Peninsula. Mar Pollut Bull. 193: 115144.

Giani D, Baini M, Galli M, Casini S and Fossi MC. (2019) Microplastics occurrence in edible fish species (*Mullus barbatus* and *Merluccius merluccius*) collected in three different geographical sub-areas of the Mediterranean Sea. Mar pollut Bull. 140: 129-137.

González-Pleiter M, Edo C, Velázquez D, Casero-Chamorro MC., Leganés F, Quesada A and Rosal R. (2020) First detection of microplastics in the freshwater of an Antarctic Specially Protected Area. Mar Pollut Bull. 161: 111811.

Hall NM, Berry KLE, Rintoul L and Hoogenboom MO. (2015) Microplastic ingestion by scleractinian corals. Mar Biol. 162: 725-732.

He B, Goonetilleke A, Ayoko GA and Rintoul L. (2020) Abundance, distribution patterns, and identification of microplastics in Brisbane River sediments, Australia. Sci Total Environ. 700: 134467.

Jabeen K, Su L, Li J, Yang D, Tong C, Mu J and Shi H. (2017) Microplastics and mesoplastics in fish from coastal and fresh waters of China. Environ Pollut. 221: 141-149.

Jovanović B. (2017) Ingestion of microplastics by fish and its potential consequences from a physical perspective. Integrated Environ Assessment Managem. 13(3): 510-515.

Julienne F, Delorme N and Lagarde F. (2019) From macroplastics to microplastics: Role of water in the fragmentation of polyethylene. Chemosphere 236: 124409.

Kataoka T, Nihei Y, Kudou K and Hinata H. (2019) Assessment of the sources and inflow processes of microplastics in the river environments of Japan. Environ Pollut. 244: 958-965.

Kiss T, Fórián S, Szatmári G and Sipos G. (2021) Spatial distribution of microplastics in the fluvial sediments of a transboundary river–A case study of the Tisza River in Central Europe. Sci Total Environ. 785: 147306.

Kleinschmidt JM and Janosik AM. (2021) Microplastics in Florida, United States: A case study of quantification and characterization with intertidal snails. Front Ecol Evol. 9: 638.

Koongolla JB, Lin L, Yang CP, Pan YF, Li HX, Liu S and Xu XR. (2022) Microplastic prevalence in marine fish from onshore Beibu Gulf, South China Sea. Front Mar Sci. 9: 964461.

Kutralam-Muniasamy G, Pérez-Guevara F, Elizalde-Martínez I and Shruti VC. (2020) Review of current trends, advances and analytical challenges for microplastics contamination in Latin America. Environ Pollut. 267: 115463.

Lampitt RS, Fletcher S, Cole M, Kloker A, Krause S, O'Hara F and Whyle A. (2023) Stakeholder alliances are essential to reduce the scourge of plastic pollution. Nature Communications 14(1): 2849.

Li LA, Xu R, Jiang L, Xu EG, Wang M, Wang J and Wang Y. (2021) Effects of microplastics on immune responses of the yellow catfish *Pelteobagrus fulvidraco* under hypoxia. Front Physiol. 12: 753999.

Liu Y, Li R, Yu J, Ni F, Sheng Y, Scircle A and Zhou Y. (2021) Separation and identification of microplastics in marine organisms by TGA-FTIR-GC/MS: A case study of mussels from coastal China. Environ Pollut. 272: 115946.

Mackenzie CM and Vladimirova V. (2023) Preliminary study and first evidence of presence of microplastics in terrestrial herpetofauna from Southwestern Paraguay. Stud Neotropical Fauna Environ. 58(1): 16-24.

Mancuso M, Nibali VC, Porcino N, Branca C, Natale S, Smedile F and Bottari T. (2023) Monitoring of anthropogenic microplastic pollution in antarctic fish (*Emerald rockcod*) from the Terranova Bay after a quarter of century. Sci Total Environ. 904: 167244.

Menéndez-Manjón, A, Martínez-Díez R, Sol D, Laca A, Laca A, Rancaño A and Díaz M. (2022) Long-term occurrence and fate of microplastics in WWTPs: a case study in Southwest Europe. Appl Sci. 12(4): 2133.

Montecinos S, Gil M, Tognana S, Salgueiro W and Amalvy J. (2022) Distribution of microplastics present in a stream that receives discharge from wastewater treatment plants. Environ Pollut. 314: 120299.

Moreschi AC, Callil CT, Christo SW, Junior ALF, Nardes C, de Faria É and Girard P. (2020) Filtration, assimilation and elimination of microplastics by freshwater bivalves. Case Studies Chemical Environ Engineer. 2: 100053.

Naidoo T and Glassom D. (2019) Sea-surface microplastic concentrations along the coastal shelf of KwaZulu–Natal, South Africa. Mar Pollut Bull. 149: 110514.

Naidoo T, Thompson RC and Rajkaran A. (2020) Quantification and characterization of microplastics ingested by selected juvenile fish species associated with mangroves in KwaZulu- Natal, South Africa. Environ Pollut. 257: 113635.

Nel HA and Froneman PW. (2015) A quantitative analysis of microplastic pollution along the south-eastern coastline of South Africa. Mar Pollut Bull. 101(1): 274-279.

Okamoto K, Nomura M, Horie Y and Okamura H. (2022) Color preferences and gastrointestinal- tract retention times of microplastics by freshwater and marine fishes. Environ Pollut. 304: 119253.

Park TJ, Lee SH, Lee MS, Lee JK, Lee SH and Zoh KD. (2020) Occurrence of microplastics in the Han River and riverine fish in South Korea. Sci Total Environ. 708: 134535.

Pazos RS, Bauer DE and Gómez N. (2018) Microplastics integrating the coastal planktonic community in the inner zone of the Río de la Plata estuary (South America). Environ Pollut. 243: 134-142.

Phuong NN, Duong TT, Le TQ, Hoang TK, Ngo HM, Phuong NA and Sempere R. (2022) Microplastics in Asian freshwater ecosystems: current knowledge and perspectives. Sci Total Environ. 808: 151989.

Piyawardhana N, Weerathunga V, Chen HS, Guo L, Huang PJ, Ranatunga RRMKP and Hung CC. (2022) Occurrence of microplastics in commercial marine dried fish in Asian countries. J Hazardous Materials 423: 127093.

Preston-Whyte F, Silburn B, Meakins B, Bakir A, Pillay K, Worship M and Maes T. (2021) Meso-and microplastics monitoring in harbour environments: A case study for the Port of Durban, South Africa. Mar Pollut Bull. 163: 111948.

Reed S, Clark M, Thompson R and Hughes KA. (2018) Microplastics in marine sediments near Rothera research station, Antarctica. Mar Pollut Bull. 133: 460-463.

Rochman CM, Brookson C, Bikker J, Djuric N, Earn A, Bucci K and Hung C. (2019) Rethinking microplastics as a diverse contaminant suite. Environ Toxicol Chem. 38(4): 703-711.

Samandra S, Johnston JM, Jaeger JE, Symons B, Xie S, Currell M and Clarke BO. (2022) Microplastic contamination of an unconfined groundwater aquifer in Victoria, Australia. Sci Total Environ. 802: 149727.

Sin LT, Balakrishnan V, Bee ST and Bee SL. (2023) A review of the current state of microplastic pollution in South Asian Countries. Sustainability 15(8): 6813.

Sparks C and Immelman S. (2020) Microplastics in offshore fish from the Agulhas Bank, South Africa. Mar Pollut Bull. 156: 111216.

Staichak G, Ferreira-Jr AL, Silva ACM, Girard P, Callil CT and Christo SW. (2021) Bivalves with potential for monitoring microplastics in South America. Case Studies Chem Environ Engineer. 4: 100119.

Su L, Nan B, Hassell KL, Craig NJ and Pettigrove V. (2019) Microplastics biomonitoring in Australian urban wetlands using a common noxious fish (*Gambusia holbrooki*). Chemosphere 228: 65-74.

Tang KHD. (2023) Microplastics in and near landlocked countries of Central and East Asia: A review of occurrence and characteristics. Tropical Aquat Soil Pollut. 3(2): 120-130.

Tata T, Belabed BE, Bououdina M and Bellucci S. (2020) Occurrence and characterization of surface sediment microplastics and litter from North African coasts of Mediterranean Sea: Preliminary research and first evidence. Sci Total Environ. 713: 136664.

Toner K and Midway SR. (2021) Historic fish samples from the Southeast USA lack microplastics. Sci Total Environ. 776: 145923.

Van der Hal N, Ariel A and Angel DL. (2017) Exceptionally high abundances of microplastics in the oligotrophic Israeli Mediterranean coastal waters. Mar Pollut Bull. 116(1-2): 151- 155.

Waller CL, Griffiths HJ, Waluda CM, Thorpe SE, Loaiza I, Moreno B and Hughes KA. (2017) Microplastics in the Antarctic marine system: an emerging area of research. Sci Total Environ. 598: 220-227.

Wang F, Lai Z, Peng G, Luo L, Liu K, Huang X and Li D. (2021) Microplastic abundance and distribution in a Central Asian desert. Sci Total Environ. 800: 149529.

Wang Q, Guan C, Han J, Chai M and Li R. (2022) Microplastics in China Sea: analysis, status, source, and fate. Sci Total Environ. 803: 149887.

Wang Y, Okochi H, Tani Y, Hayami H, Minami Y, Katsumi N, Takeuchi M, Sorimachi A, Fujii Y, Kajino M, Adachi K, Ishihara Y, Iwamoto Y and Niida Y. (2023) Airborne hydrophilic microplastics in cloud water at high altitudes and their role in cloud formation. Environ Chem Lett. 21: 3055-3062.

Webb S, Gaw S, Marsden ID and McRae NK. (2020) Biomarker responses in New Zealand green-lipped mussels Perna canaliculus exposed to microplastics and triclosan. Ecotoxicol Environ Saf. 201: 110871.

Wootton N, Ferreira M, Reis-Santos P and Gillanders BM. (2021) A comparison of microplastic in fish from Australia and Fiji. Front Mar Sci. 8: 690991.

Wootton N, Reis-Santos P, Dowsett N, Turnbull A and Gillanders BM. (2021) Low abundance of microplastics in commercially caught fish across southern Australia. Environ Pollut. 290: 118030.

Wright SL, Thompson RC and Galloway TS. (2013) The physical impacts of microplastics on marine organisms: A review. Environ Pollut. 178: 483-492.

Yagi M, Kobayashi T, Maruyama Y, Hoshina S, Masumi S, Aizawa I and Shimizu K. (2022) Microplastic pollution of commercial fishes from coastal and offshore waters in southwestern Japan. Mar Pollut Bull. 174: 113304.

Yang W, Li Y and Boraschi D. (2023) Association between microorganisms and microplastics: How does it change the host–pathogen interaction and subsequent immune response?. Int J Molec Sci. 24(4): 4065.

Yick JL and Travers T. (2022) The ingestion of large plastics by recreationally caught southern bluefin tuna *Thunnus maccoyii* off southern Australia. Mar Pollut Bull. 175: 113332.

Zhang S, Zhang W, Ju M, Qu L, Chu X, Huo C and Wang J. (2022) Distribution characteristics of microplastics in surface and subsurface Antarctic seawater. Sci Total Environ. 838: 156051.

Zhu W, Liu W, Chen Y, Liao K, Yu W and Jin H. (2023) Microplastics in Antarctic krill (*Euphausia superba*) from Antarctic region. Sci Total Environ. 870: 161880.

Zhu W, Zhao N, Liu W, Guo R and Jin H. (2023) Occurrence of microplastics in Antarctic fishes: Abundance, size, shape, and polymer composition. Sci Total Environ. 903: 166186.

Zobkov M and Esiukova E. (2017) Microplastics in Baltic bottom sediments: quantification procedures and first results. Mar Pollut Bull. 114(2): 724-732.