AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly e Newsletter
Volume 2 – Issue 11
Online ISSN: 2582-368X
www.agriallis.com

MICROPLASTIC IN MARINE ECOSYSTEM AND ITS IMPACT IN HUMAN HEALTH

Article Id: AL202119

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Plastic production has increased and exponentially reached 322 million tonnes in 2015 since the early 1950, and additionally production of synthetic fibres which consider for 61 million tonnes in 2015. It is expected that by 2025 production of plastics will be double and continue to increase in the expected future. Contamination of freshwater, estuarine and marine environments increased consistently due to insufficient management of plastic waste. It has been roughly calculated that in 2010 between 4.8 million to 12.7 million tonnes of plastic waste entered the oceans. Microplastics are generally defined as a group of plastic items which measure less than 5 mm, and this definition also includes nanoplastics which consist of particles less than 100 nanometres. It is evaluated that, in the marine environment, plastics take hundreds to thousands of years to degrade, with reporting the presence of microplastics in lake sediment that had been accumulating for 38 years. In wild and marine aquatic organisms, microplastics have only been observed within the gastrointestinal tract. The risk of microplastic ingestion in human can be limited by the eradication of the gastrointestinal tract in most species of seafood consumed. But most species of seafood such as bivalves and many species of small fish are consumed entirely, without removing G.I. tract, which may lead to microplastic exposure to human. A rough case estimate of exposure to microplastics after consumption of a portion of mussels (225 g) would lead to ingestion of 7 micrograms of plastic, which would have a minor effect (less than 0.1 percent of total dietary intake) on chemical exposure to certain PBTs and plastic additives. Microplastic contamination of aquatic environments will continue to increase in the expected future due to anthropogenic activity, and at present, there are remarkable knowledge gaps on the occurrence of smaller sized microplastic less than 150 µm in aquatic environments and organisms. Currently, there are no methods available for the examination and quantification of nanoplastics in aquatic environments and organisms.

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Online ISSN: 2582-368X
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Plastic in ocean

Plastic materials are used in boat construction, boat maintenance, fishing gears (nets, trawls, dredges, traps, floats, lures, hook and lines), fish crates and fish hold insulation. A range of plastics, including PP, PE, PVC, PS and PA, are used for the manufacturing of nets and floats, and the choice of fishing method or gear type is critical depend for both its use in fishing and its impact on the environment. Plastic materials are used for the seafood industry for packaging and transportation, ropes, floats, fish crates and boxes, fish cages, pond lining, fish feeders and fish tanks. Plastics are used for the manufacturing of cages, nets, ropes, lines and buoys: this includes small domiciliary facilities to highly technical systems used in fish culture and processing.

Around the globe, plastic items are consistently the most abundant type of marine debris identified in the marine environment, and can contribute to more than 80 percent of reported debris. Unprotected landfills and dumps located near the coast or to riverine systems that directly inlet by metro cities, general public litter in shorelines, accidental loss, harbour activities, improper management of sewage systems are the Land-based sources of marine pollution. Plastic litter can be generated from all types of boats, ships and offshore platforms in the ocean are Oceanic based source of marine pollution. This can be occurred by accidental loss, indiscriminate disposal or illegal dumping. The disposal of waste from vessels now prohibited by the International Convention for the Prevention of Pollution from Ships.

Lost or otherwise discarded fishing gears are the main source of plastic waste into the ocean. Irregularities on the seafloor will most commonly affect the Trawls, dredges and pots. A significant component of Abandoned, lost or otherwise discarded fishing gear (ALDFG) are geared such as gillnets, trawls, handlines and longlines. Loss of fishing gears in the ocean can be a result of enforcement on fishers to strand gears (e.g. illegal gears or illegal fishing), operative pressure (e.g. use of a large number of gears in restricted time periods) and environmental conditions (e.g. weather, seabed irregularities). Derelict fishing gears dominate the seafloor, for eg., estimated that overall debris on the seabed of the Mediterranean Sea and Northeast Atlantic was contributed mainly of plastics (41 percent) and ALDFG (34 percent), but in some places, such as north of the Faroe Islands, the Norwegian continental shelf, ALDFG contributes more than 75 percent of marine debris in the marine environment. ALDFG is a major issue for fisheries and marine conservation, its presence in

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Online ISSN: 2582-368X
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the marine environment can have a significant impact on shellfish industry and commercial fishing and also on the environment. It can lead to ghost fishing, the capture of non-target aquatic species, stock exhaustion, conservation discuss, the threat to other vessels, and it is costly to remove.

Fig 1: Crabs and different aquatic organism caught in ALDFG in the ocean. (Source: FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 615)

Uptake of microplastic by aquatic organism

A broad range of species fishes that were reported to be contaminated with microplastics and occupy a large variety of habitats in marine environments. Microplastics exhibit considerable differences in colour, shape, and polymer that detected in these wild-caught fishes also. The most commonly detected shapes of microplastics in fish are fibre and fragment, which go in accordance with their prevalence in global waters. The most produced polymers around the world are polyethene, polypropylene, polyester, and polystyrene, are also usually present in the digestive tracts of fish. After ingestion of microplastics, it retained in the digestive systems of fish, including the stomach and intestine. Additionally, microplastics can also attach to the skin of fish or migrate to other tissues, such as gills, liver, and muscle. It has been considering that very fine plastic particle could migrate across living cells into the circulatory or lymphatic system, resulting in dispersion of microplastics

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throughout the whole body. Scientific reports showed that plastic fragments and fine particles blocked the movement of food materials in the gut leading to reduced food intake, increase starvation, physiological stress, reduction in fertility, pseudo-satiety sensation, fecundity and finally increase in morbidity and mortality.

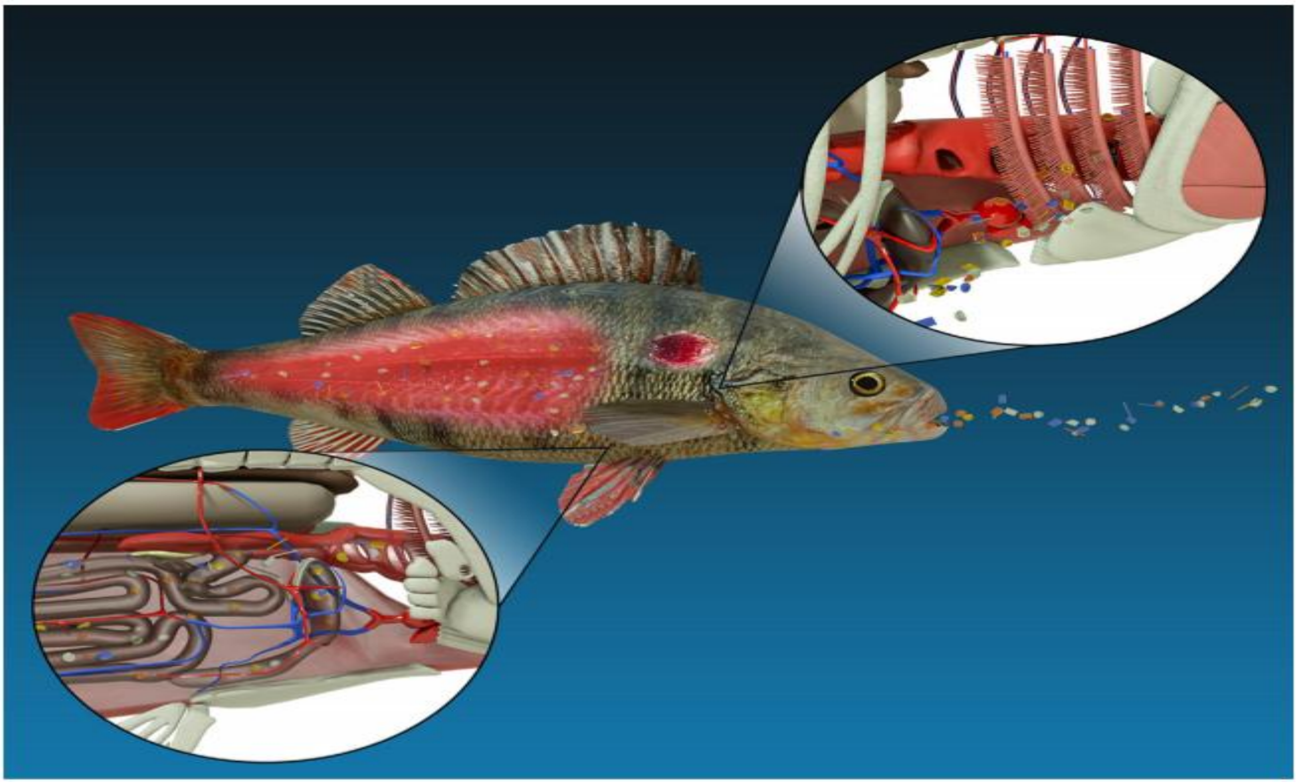

Fig 2: Microplastic uptake by fish. (Source: Barboza et al., 2020)

Accumulation of microplastics through trophic transfer

Persistent, bioaccumulative and toxic substances **(**PBTs) build up in the tissues of organisms and accumulate up the food chain, leading to increased body burdens in higher trophic levels or in higher animals. If the trophic transfer in the food chain were to occur regularly, animals at higher trophic levels such as carnivorous animals, human etc. would be at increased risk of bad impacts and results, such as damage to and irritation of the gut lining and reduced nutrient uptake. Microplastics have been noticed in large pelagic fish, and it has been proposed that microplastics present in these species may have transferred from prey items rather than from directly feeding in the environment.

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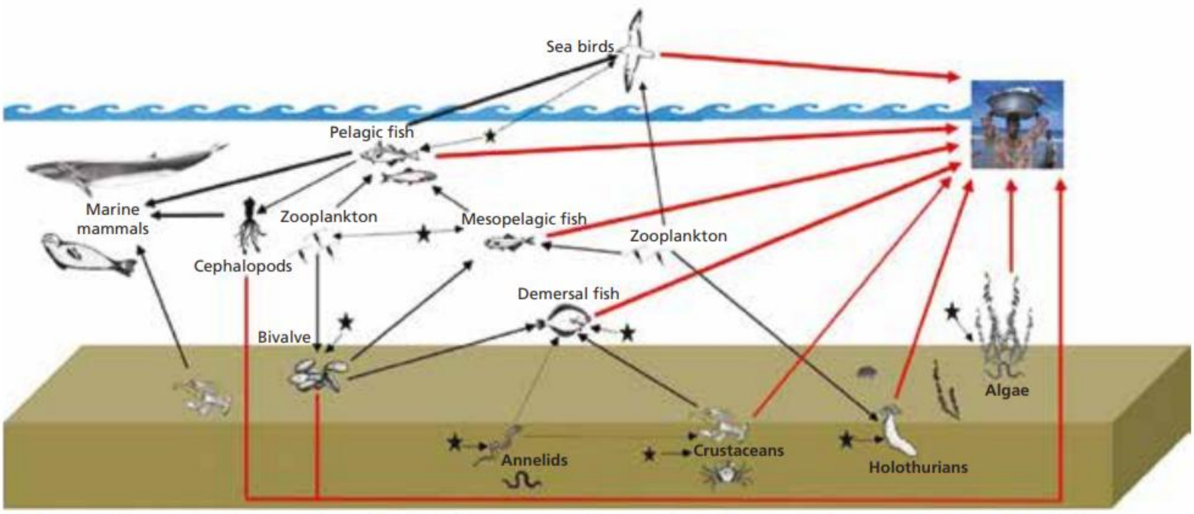

Black stars represent microplastic particles and the black dotted arrows indicate an observed interaction between organism and particle (direct ingestion/uptake). The black arrows indicate indirect ingestion of MPs (potential trophic transfer). The red lines indicate potential route of microplastics to humans following ingestion of seafood. Finally, arrow thickness represents potential bioaccumulation of particles through the foodweb

Fig 3: Micro biota, microplastic, possible trophic pathways interaction. (Source:FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER 615)

Microplastics in foods

The increased production of fisheries and aquaculture products has resulted in increased per capita consumption globally. In 2014, for human consumption, 87 percent of total marine capture production was used and the remaining 23 percent, which accounted for 21 million tonnes of total production, was used for non-food products, especially fishmeal and fish oil. World per capita noticeable consumption of fishery products averaged around 9.9 kg, increasing to 14.4 kg and reached a value of 19.7 kg, in the 1960s, 1990s, 2013 respectively.

Ingestion of microplastics has been noticed in a relatively large number of fish species and products used for human consumption from the Pacific, Atlantic and Indian oceans. According to one research, microplastics have been observed in the gastrointestinal tract in 11 out of the 20 most important species and genera of finfish that contribute to global marine fisheries. These species are chub mackerel (*Scomber japonicus*), Atlantic mackerel (*Scomberscombrus*), Japanese anchovy (*Engraulis japonicus*), Atlantic cod (*Gadusmorhua),* Atlantic herring (*Clupea harengus*), European pilchard (*Sardinapilchardus*), blue whiting (*Micromesistiuspoutassou*), king mackerel (*Scomberomorus cavalla*) from the Scomberomorusspp group, European sprat (*Sprattussprattus*), shortfin

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Online ISSN: 2582-368X
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(*Decapterusmacrosoma*) and Amberstripe (*Decapterusmuroadsi*), and Indian oil sardine (*Sardinella longiceps*).

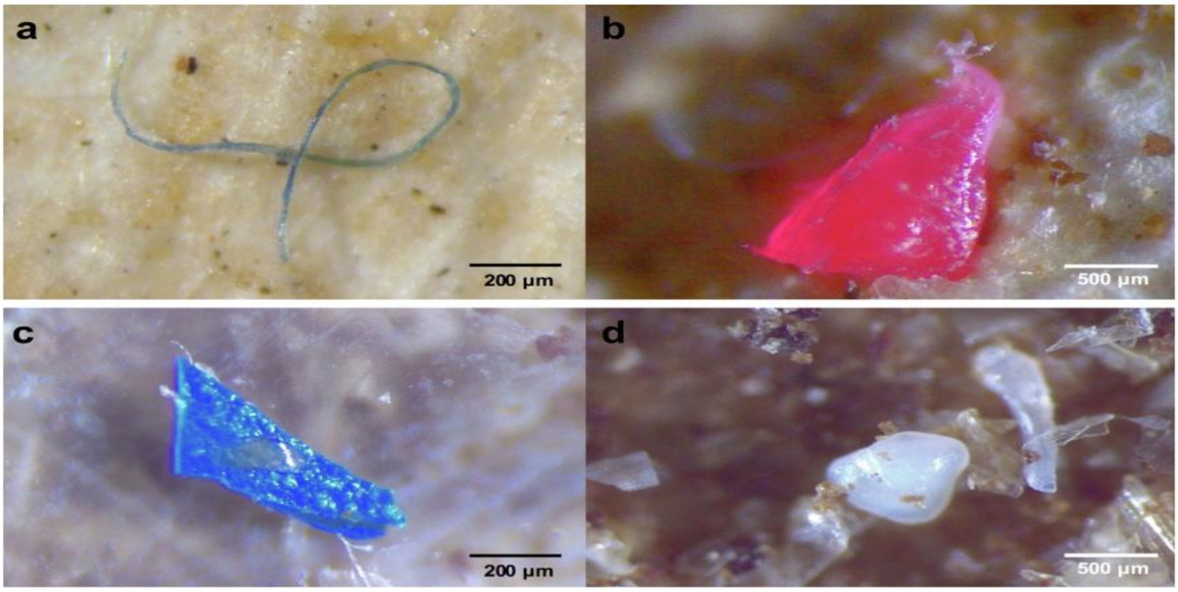

Fig 4: Microplastic recovered from different fish species, (a- fiber, b and c- fragment, d- pellet). (Source: Barboza et al., 2020)

Human exposure to microplastics through fish consumption

One major source of dietary microplastics to humans is seafood. According to one research, human intake of microplastics from seafood has been calculated from 1 particle per day to 30 particles per day depending on seafood consumption habits of the individual person. According to one study, the highest amount of microplastics is carried by Chinese bivalves: overall value of 4 particles/g of tissue. Thus, it will lead to consumption of about 900 microplastic particles by the consumption of such a portion of bivalves (225 g). It can be estimated that microplastics contribute only a very small fraction of the total dietary intake of contaminants: Polycyclic aromatic hydrocarbons (PAHs) from 0.02 % to 0.1 %, Polychlorinated biphenyls (PCBs) from 0.007 % to 0.03 %, and DDT from 0.0000002 % to 0.004 %. The contribution of microplastics in compare to the dietary intake of additives is even smaller: Bisphenol A (BPA) from 0.000005 % to 0.00002 %, and Polybrominated diphenyl ethers (PBDEs) from 0.0007 % to 0.003 %. After ingestion by marine organism, these particles could be absorbed in the small intestine by specialized M-cells, covering an intestinal lymphoid tissue – Peyer's patches, and also adherence to the gastrointestinal mucus, where high adherence increases particle clearance rate.

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Seafood Safety

The largest quantities of microplastics contain by the digestive tract of marine organisms. However, this part of marine fish is normally removed before consumption, except for most bivalves and mussels, several small species of fish which are eaten whole. A rough case estimates the exposure of 7 µg of microplastics after consumption of a portion of mussels (225 g). Based on this calculation and taking into account, the highest concentrations of additives or contaminants reported in microplastics; the microplastics will have a minor effect on the total dietary exposure to PBTs and plastic additives. These contaminants of microplastic are calculated to contribute only <0.1 % of the total dietary exposure to these plastic compounds.

As far as it is known, only microplastics which are less than 150 µm may penetrate across the mammalian gut epithelium, causing systemic exposure. However, the absorption of these microplastics is expected to be restricted (≤ 0.3 percent). Only the smallest microplastic fraction or segment (size ≤ 20 µm) may translocate into organs and cause systemic exposure in human body. Nanoparticles can penetrate across the gut epithelium of mammals resulting in systemic exposure and damage, and a very wide distribution in all organs is likely.

The overall human health risks posed by microplastics in seafood at present appear to be very less, it is important to consider the unavoidable increase of micro- and nano plastics in the future as a result of degradation of plastics already released in the marine environment as well as future inputs.

Implications for human health

Even though scientific evidence and research demonstrate the presence of microplastics in several food products, there is no information available about the fate of microplastics in the human body following ingestion of the particles. Scientists postulate that microplastics with size bigger than 150 µm probably will not be absorbed by the organism while microplastics smaller than 150 µm may penetrate from the gut cavity to the lymph and circulatory system, causing systemic exposure in the mammalian body. However, the absorption of these microplastics by food products is expected to be limited (≤0.3%). Only microplastics with size ≤ 20 µm would be able to translocate into human organs while the smallest fraction (0.1 > 10 µm) would be able to approach all organs, the blood-brain barrier,

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cross cell membrane and the placenta. If so, it is possible that the penetration of microplastics in secondary tissues, such as liver, muscle, and brain, may occur. Moreover, it is expected that interactions of micro-and nano plastic with the immune system may potentially lead to immunotoxicity and consequently trigger adverse effects in the mammalian body (i.e. Immunosuppression, abnormal inflammatory and immune activation response).

Conclusion

The increasing outbreak or use of microplastics in the environment, especially in marine environments, and their very small size on the other, have made these polymer particles to be abused by marine organisms. In this way, their access to the food chain has increased through exposing by marine biota such as phytoplankton and zooplankton. After entering the body, bioaccumulation start or microplastics can accumulate in different parts of the body in the mammalian body such as gill, gut and liver and/or cause toxic effects and bad impact by using different mechanisms that are mainly oxidative stress. Highest microplastics accumulation occur in the intestine of the organism. The natural microbiota of the gastrointestinal system in marine animals can be altered by the accumulation of microplastic.

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