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The occurrence and consequences of microplastics and nanoplastics in fish gastrointestinal tract

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Abstract

Many recent researches have been conducted on the contamination of microplastics and nanoplastics in the marine environment, focusing on the incidence of these elements ingested by fish. Numerous fish species have been found to contain microplastics and nanoplastics in their gastrointestinal tracts. This is a cause for concern when these fish are consumed by humans where > 20% of food consumption by 1.4 billion people representing 19% of the global population, is seafood. The aim of this paper is to emphasize the occurrences and implications of microplastic and nanoplastic bioaccumulation and biomagnification in fish species. This paper will review findings on how the concentration of microplastics and nanoplastics in fish gastrointestinal tracts have detrimental influences on the fish, other animals, and humans. Past studies have found that there are 37 species of fish having microplastics and nanoplastics in their gastrointestinal tracks. These contaminated fish species are found to be distributed in a broad geographical area ranging from the Adriatic Sea and Baltic Sea to Tokyo Bay. The bioaccumulation, and biomagnification of microplastic and nanoplastics, toxins and chemical leaching of plastic additives have high potential health consequences on consumers in higher trophic levels. Examples of findings include microplastic accumulation of polystyrene in the liver and intestines of fish may cause liver toxicity, inflammation and lipid accumulation, oxidative stress and alterations in metabolic profiles as well as disturbance of lipid and energy metabolism in humans. Exposure to microplastics in water and food can affect the hatching performance of fish eggs and result in histopathological alteration of the intestinal and hepatic tissues of fish. Microplastics can induce liver stress, distal bowel changes and minimize individual predator reaction in fish.

Keywords: Nanoplastics, Microplastics, Fısh, gastrointestinal tract

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Introduction

The use of plastic in the 20th century became widespread due to its low density, high strength to weight ratio, high durability, simplicity of design and manufacturing, and low cost (Gu and Ozbakkaloglu, 2016). There are two large groups of plastics, thermoplastics and thermosets. Thermoplastics are a group of plastics which can constantly be reheated, reshaped and frozen. Among the types of plastics that belong to this group are Polyethylene (PE), Polyamides (PA), Polypropylene (PP), Polycarbonate (PC), ABS, EVOH, PBT, SAN, PEEK, POM, Expanded polystyrene (EPS), Polyarylsulfone (PSU), Polystyrene (PS), Thermoplastic elastomers (TPE), Polyethylene Terephthalate (PET), Poly methyl methacrylate (PMMA), Polyvinyl-chloride (PVC) and Fluoropolymers. Meanwhile, thermoset is a group of plastics that undergo chemical changes during heating. These plastics cannot be re-melted and reformed after heating and forming. Plastics that belong to this group are Epoxy resins, Vinyl esters, Silicone, Melamine resin, unsaturated polyesters, Phenolic resins, Polyurethane (PUR), Urea-formaldehyde resins, Acrylic resins, and Phenol - formaldehyde resins (PlasticsEurope, 2019).

Plastic production has increased globally from 348 million tonnes in 2017 to 359 million tonnes in 2018. In 2018, Asia accounted for 51% of world plastic production, while 18% in the North American Free Trade Agreement (NAFTA), Europe (17%), Middle East and Africa (7%), Latin America (4%) and the Commonwealth of Independent States (CIS) accounted for 3% (PlasticsEurope, 2019). According to Geyer *et al*. (2017), plastics have outpaced most man-made products and have long been a critical observation under the environment. The beginnings of the global plastics industry have begun since Bakelite invented the first synthetic plastics in 1907. However, the exponential growth of global plastics production was only realized in the 1950s (Ritchie and Roser, 2018). The fact that plastic waste has spread throughout the world (Law, 2017) and it is not surprising. The certain plastics are decomposed into secondary microplastic particles (MPs) and nanoplastics (Silva *et al*., 2018; Peng *et al*., 2020) and according to Chubarenko *et al*. (2016), the composition of plastic waste in the marine environment can be decomposed by physical, biological and chemical processes. As a result, plastic fragments come in various of shapes, ranging from metres to nanometres.

Presently, Sherman and van Sebille (2016) say that rising plastic accumulation in the oceans is an urgent issue that needs immediate consideration. Todays, plastic solid waste has become a worldwide threat with global production of plastics has grown exponentially over the last 50 years (Gu and Ozbakkaloglu, 2016). Plastic waste can be found not only accumulated on land, but also in the marine environment. This happens as human-consumed plastic waste is disposed of or inappropriately handled

(Jambeck *et al*., 2015). In the oceans alone, as much as 10% of the overall plastic waste has reached the oceans of the world (da Costa *et al*., 2017). It is estimated that 5 to 13 Tg of plastic has entered the oceans every year (Boucher and Friot, 2017). Jambeck and Johnsen (2015) have reported that these sea-based plastic debris can be found in marine areas around the world. It can also be found in sedimentary fjords, estuaries, offshore coastal zones, continental shelves (Harris, 2020) and in the deepest parts of the ocean (Chiba *et al*., 2018).

The Sea Debris Database, which has been accumulated since 1983 by the Global Oceanographic Data Center (GODAC) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), has recorded a total of 3425 man-made debris pieces. Among these, 33% are macro plastic debris, in which 89% are disposable goods, and in areas deeper than 6000m this percentage raises up to 52% and 92%. The deepest record is the plastic bag in the Mariana Trench at 10898m and the deep-sea plastic density in the North Pacific ranges from 17 to 335 items km−2 (Chiba *et al*., 2018). These plastic debris can be seen in the sea due the flow of the river has transported them to the sea (Lebreton *et al*., 2017) with the first existence of these debris was detected or recorded in the 1970s (Carpenter *et al*., 1972). All of these ocean plastic debris is a significant threat to global marine environment and negatively impacted marine life and human health (Jiang, 2018; Tavares *et al*., 2020). It has been approved that this plastic depris had a negative effect on marine life as it has been found that there are small pieces of plastic in the gastrointestinal tract of more than 2200 different marine species. They range from zooplankton to alpha predators or also known as top predators (Jepsen and de Bruyn, 2019; Tekman *et al*., 2020). Among the marine animals affected by depressive plastics such as microplastics are fish which based on a study conducted by Campbell *et al*. (2017) have found that there is microplastics in the gastrointestinal tract of fish. Worryingly, these microplastic and nanoplastic particles may pass through the food chain to the apex predatorsat or the human food chain through other pathways (Yang *et al*., 2015; Zhu *et al*., 2018) which will have a detrimental influence on animals and humans.

For this review paper, it is therefore important to highlight the occurrence and consequences of bioaccumulation and biomagnification of global marine plastic debris such as microplastics and nanoplastics in marine animals. However, this study will only focus on fish by looking at microplastics and nanoplastics in their gastrointestinal tract. This paper review will also show how the microplastic and nanoplastic content in their gastrointestinal tract has had a negative impact on the fish itself, other animals and humans.

The emergence of microplastics (MPs) and nanoplastics debris in the marine environment

The origin and types of plastics (microplastics and nanoplastics)

According to Rios *et al*. (2007) and Thompson *et al*. (2009), plastics are derived from synthetic organic polymers derived from the polymerization of monomers produced from oil or gas. Plastics can be classified according to the size of the measurements such as macroplastics, mesoplastics, microplastics and nanoplastics. The sizes of macroplastic are >200 mm, mesoplastic from 5 to 200 mm, microplastic from 1 μm to 5 mm and nanoplastic are <1μm in diameter (da Costa *et al*., 2016; Eriksen *et al*., 2014). Other studies also defined, Microplastics (MPs) are small pieces of plastic (~50 μm) which are first used in 2004 (Thompson *et al*., 2004; Zhang *et al*., 2020) and can be classified based on shape, color, and size (Duis and Coors, 2016; Zhang *et al*., 2020), as well as different specific density and chemical composition (Duis and Coors, 2016). This vast quantity of plastic has caused marine mammals to be entangled in plastic detritus and to be exposed to plastic pollution (Wilcox *et al*., 2015). The small size of microplatics caused swallowing by certain marine species and caused direct physical harm and potential toxic effects (Wright *et al*., 2013).

Meanwhile according to Koelmans *et al*. (2017), macroplastics are plastics measuring>5 mm while microplastics are measuring 335 µm - 5 mm. There are two categories of plastics, namely primary plastics and secondary plastics (Auta *et al*., 2017) where plastics that fall under the category of primary plastics are microplastics and nanoplastics. Microplastic that entering the oceans exists after the fragmentation process of larger plastic particles (Barnes *et al*., 2009; Koelmans *et al*., 2017). Microplastic contaminants can be transferred to the sea by larger plastic particles from landfills which have been broken down into smaller debris (Alomar *et al*., 2016). Microplastics and nanoplastics can be found in personal care products (Rochman *et al*., 2015; Hernandez *et al*., 2017). Among the personal care products that contain microplastics include face wash and cosmetics (Zitko and Hanlon, 1991) as well as as in 1990s microplastics can be found in a scrubber in hand exfoliators and face cleansers (Derraik, 2002; Fendall and Sewell, 2009). In addition, microplastics can also be used in pharmaceutical goods as a vector for drugs (Patel *et al*., 2009). Whereas secondary plastics are degradation by larger plastics crushing or other products (Capolupo *et al*., 2020; Huang *et al*., 2020).

Globally estimated, the total global release of primary microplastic to the ocean is 1.5 million tonnes per year which is estimated to be between 0.8 and 2.5 Mtons per year (Boucher *et al*., 2017). Microplastics can be found in freshwater and marine organisms (Kako *et al*., 2014; Isobe *et al*., 2014), open oceans (Andrady, 2011), beaches/ seashores (Yu *et al*., 2018b), bay (Frère *et al*., 2017), water columns and sediments (Hidalgo-Ruz *et al*., 2012; Thompson *et al*., 2004), estuaries (Zhao *et al*., 2015), deep sea sediments (Bergmann *et al*., 2017), lakes (Su *et al*., 2016), inland rivers (Wang *et al*., 2017) and frozen ice which some of it floating on surface waters (Lusher *et al*., 2015). In enclosed or semi-enclosed seas such as the Caribbean and the Mediterranean Sea, and in gyros (Karapanagioti, 2012; Barnes *et al*., 2009; Collignon *et al*., 2012) and even in manufacturing centers and metropolitan areas (Claessens *et al*., 2011; Vianello *et al*., 2013), high concentrations of microplastics were detected.

The presence of micro-plastics is also related to other factors such as the level of urbanization and population growth (Sruthy and Ramasamy, 2017; Vaughan *et al*., 2017), tourism activities such as at remote lakes in Mongolia and Italy (Free *et al*., 2014; Imhof *et al*., 2013), marine transport industry (Yu *et al*., 2018a) and tourism activities carried out in coastal areas where the abundance of micro-plastics incresing if receives more visitors (Costa *et al*., 2010) (Figs. 1 to 3).

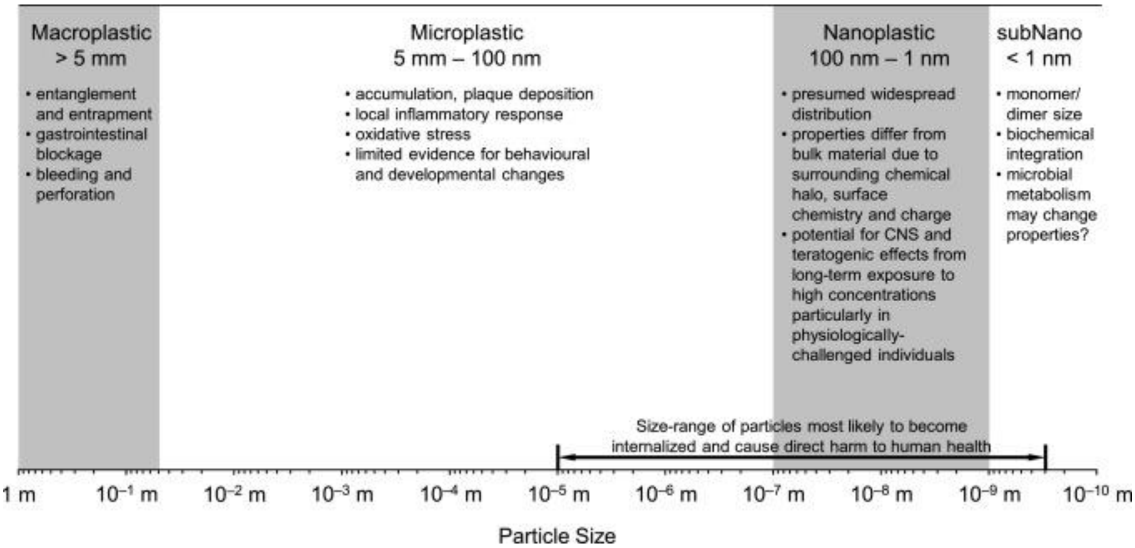

Figure 1: Types of plastic (Warring *et al*., 2018)

Bioaccumulation and Biomagnification

Bioaccumulation is the mechanism by which the quantity of plastic particles in the body increases steadily when the rate of absorption exceeds the rate of elimination from the body. While biomagnification is defined as the accumulation of the material across the food chain by transmitting the residue from the diet to the body tissue. The concentration of tissue rises at each trophic stage in the food web as uptake exceeds elimination (Ng *et al*., 2018). These two concept (bioaccumulation and biomagnification) are two important principles used in the ecological risk assessment to determine the extent to which contaminants are transported in food webs (Mackay and Boethling, 2000). Bioaccumulation may also be seen to occur where the absorption of contaminants is higher than the ability of the organism to eliminate contaminants (Wang *et al*., 2016). In last, the bioaccumulation and subsequent trophic of contaminant transportation can result in the biomagnification of these contaminants at higher trophic levels (Kelly *et al*., 2007) therefore bioaccumulation and biomagnification of these toxic contaminants have the potential to harm marine organisms as well as humans.

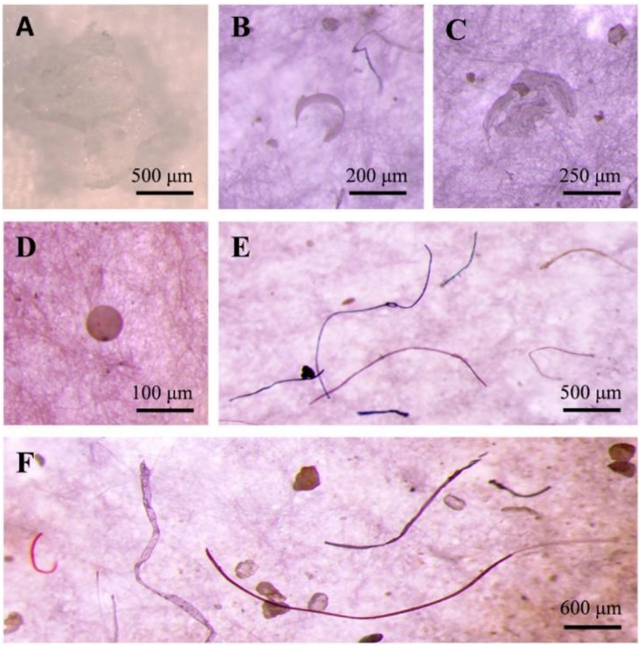

Figure 2: The optical microscope images of selected microplastics: A–B: fragment, C: film, D: particle, D–F: fiber (Zhao *et al*., 2018).

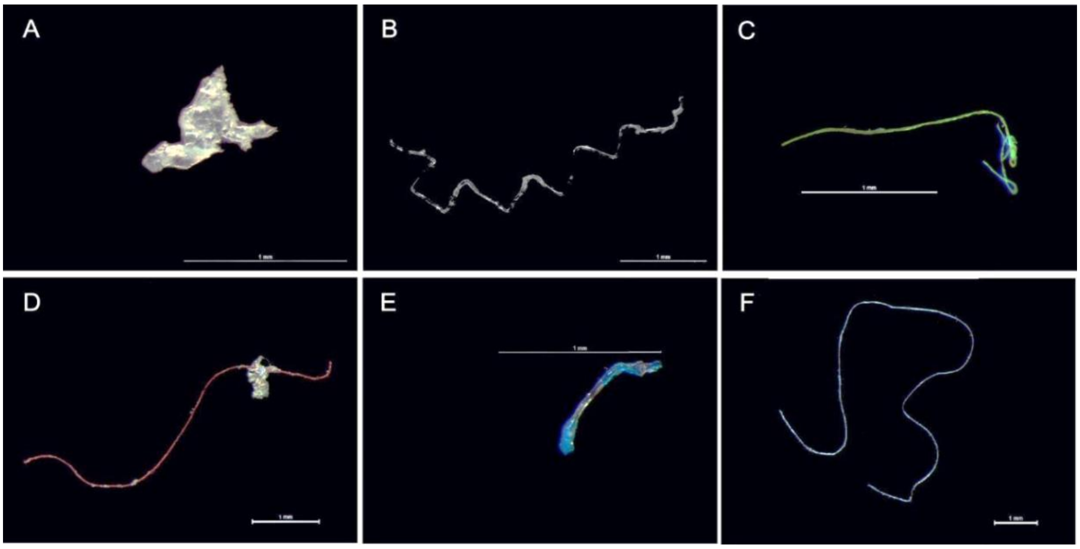

Figure 3: Microplastics found in the gastrointestinal tract of fish. A: Polyethylene, B: Polypropylene, C: Rayon, D: Polyester, E: Polyacrylonitrile and F: Nylon (Bessa *et al*., 2018).

Nanoplastics have been shown to substantially increase phenanthrene bioaccumulation in Daphnia Magna and to cause increased toxicity to daphnids

(Ma *et al*., 2016). Also, studies have shown that there is a higher bioaccumulation of microplastics in fish larvae from the English Channel (Steer *et al*., 2017) than adult fish from the North Pole (Morgana *et al*., 2018). Figure 4 illustrates the scenario in which organic plastic-derived chemicals will transfer to lower trophic-level species by absorption and accumulate at far higher concentrations by biomagnification at higher trophic levels. In this case, Rochman (2015) organic chemicals used as examples are (PAHs), lower trophic-level organisms represented by zooplankton and higher trophic-level organisms represented by small fish and sharks. The transfer of these chemicals to higher trophic-level organisms can contribute to contamination of seafood, which is then consumed by humans. It may be said that humans consume infected seafood caused by plastic contamination in seafood nets. Figure 4 also displays the different thick and thin arrow sizes that demonstrate how the body load (i.e. bioaccumulation of chemicals) can increase in predators compared to their prey (Rochman, 2015). Figure 5 shows how Microplastics and nanoplastics enter the human body through the intake of contaminated seafood (i.e. fish, shrimp) (Paul *et al*., 2020).

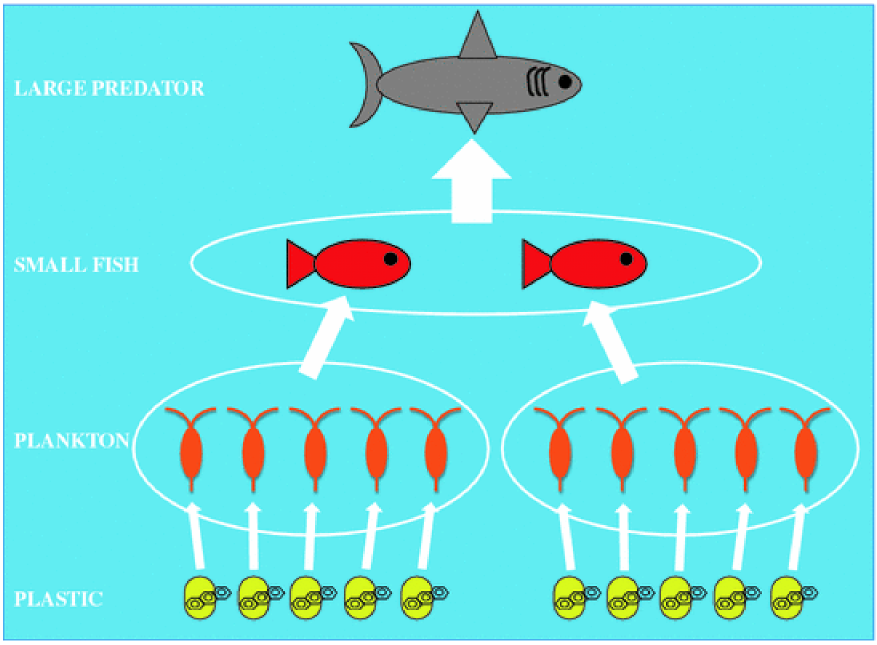

Figure 4: Biomagnification of chemicals/contaminants up the food chain (Rochman, 2015).

Microplastics and nanoplastics contaminants in fish Gastrointestinal Tract

Recently the whole world has begun to pay attention and worry about the presence of microplastics and environmental problems that have arisen due to negative impacts of these microplastics (Faggio *et al*., 2018; Sehonova *et al*., 2018) as well as negative impacts arising from nanoplastics (Chang *et al*., 2020). These concerns may be due to a spike in human beings by inaccurate consumption or food webs as a result of microplastic threats to aquatic organisms, birds, mammals and humans (Wright *et al*., 2013; Miranda and de Carvalho-Souza, 2016). Bivalves, zooplankton, mussels, fishes, shrimps, oysters, copepods, lugworms, barnacle sea cucumbers, amphipods and whales are among the marine/aquatic life that have been documented to ingest microplastics (Cole *et al*., 2013; Goldstein and Goodwin, 2013; Lusher *et al*., 2015; Ferreira *et al*., 2016; Rehse *et al*., 2016). Thus, plastic waste has become a serious threat to the environment (Prokić *et al*., 2019; Strungaru *et al*., 2019).

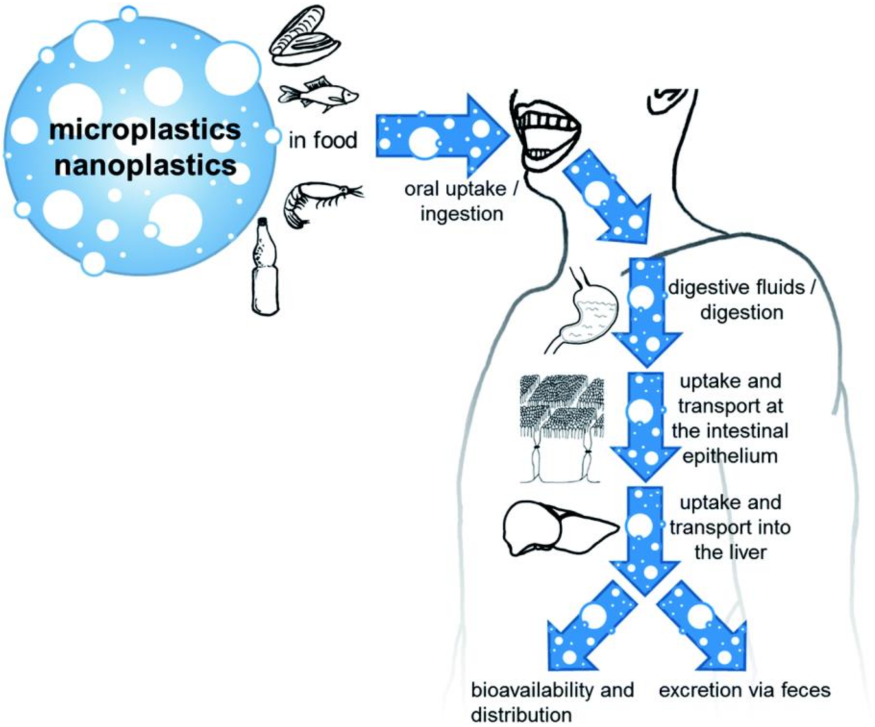

Figure 5: Human exposure and the path of microplastics and nanoplastic particles in the human body by human oral exposure (Paul *et al*., 2020).

The first study on plastic fragments in fish was made by Carpenter *et al*. (1972) in which they has taken sea fragments by fish and described the presence of plastic particles in larvae and adult fish namely Winter flounder and grubby larvae contained spherules 0.5 mm in diameter. According to Andrady (2011) and Cole *et al*. (2011), microplastics are known to be readily bioavailable to organisms in the food web due to their small size and low density (Bouwmeester *et al*., 2015) as well as microplastic intake very bioavailable by marine organisms can be direct and indirect through trophic transfer from contaminated prey (Nems *et al*., 2018). The reason for direct intake is due to the likelihood of active selection due to inaccurate detection of microplastics as food (Neves *et al*., 2015; Lönnstedt and Eklöv, 2016) or unintentional use of particles by means of indiscriminate feeding strategies (Besseling *et al*., 2015) (Fig. 6).

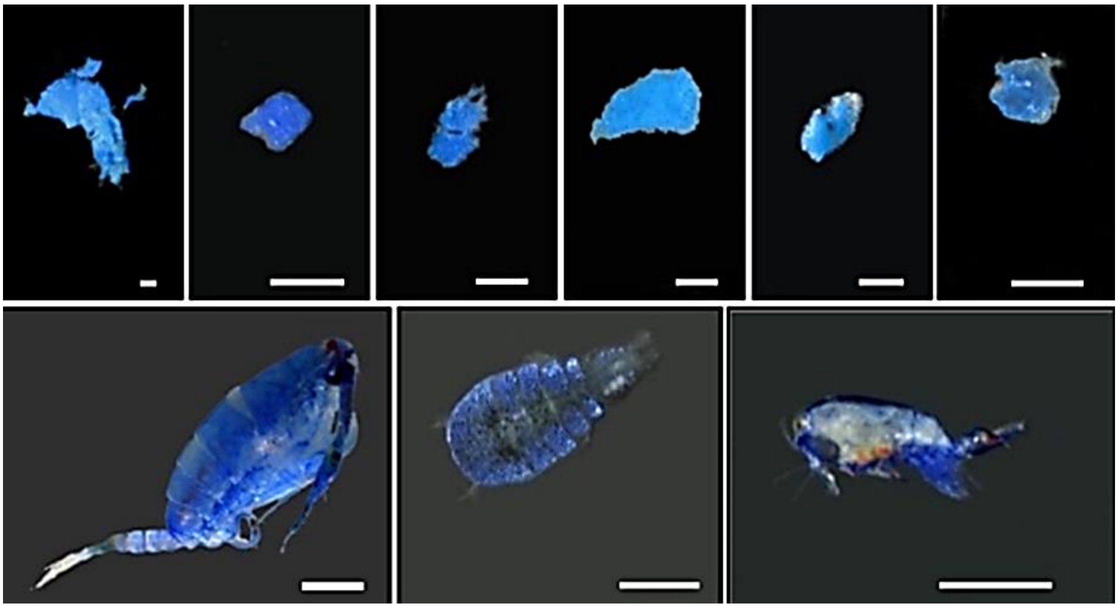

Figure 6: Amberstripe scad Decapterus muroadsi (Carangidae) fish confused with natural prey and blue microplastics (Ory *et al.*, 2017)

A research undertaken by Neves *et al*. in 2015 found 17 species (19.8% are fish) with 32.7% of these species ingest more than one microplastic. A total of 63.5% were benthic species and 36.5% were pelagic species ingest microplastics. The study also identified 73 forms of microplastics, including 48 (65.8%) fibers and 25 (34.2%) fragments. Adapted from the study undertaken by Nelms *et al*. in 2018, it was found that 10 of the 31 fish analyzed contained 18 confirmed microplastic particles. The number of microplastics per fish ranged from 0 to 4 with the largest of microplastics is fiber 13 (72%) with a length of between 0.5 and 6.0 mm, while the fragments being 5 (28%) with the largest proportion are 0.7 x 0.2 mm and the smallest 0.1×0.1 mm. Lusher *et al*. (2016) found that 11% of the mesopelagic fish examined contained microplastics due to the trophic transfer experience as the main route of microplastic ingestion. This amount is equivalent to about 385 million individual fish containing microplastics. An estimated 463 million microplastics can be ingested by striped dolphins (*Stenella coeruleoalba*) using contaminated prey.

There are more than 160 marine species and 39 freshwater species have been approved for microplastic ingestion (Scherer *et al*., 2017; De Felice *et al*., 2019). Based on an analysis performed by Lusher *et al*. (2016), it has also been found that 84 (11.0%) of the 761 individuals fish has plastic in their digestive tract. The species with the largest proportion of plastic consumption are such as *B. Glacial* (22%), *A. Risso* (21%), and *N. Croyeri* (14.8%). Several studies have also shown that there is an accumulation of polystyrene microplastics in fish gastrointestinal tract such as a study conducted by (Lu *et al*., 2016) which found the existence of polystyrene microplastics accumulated in the gills, liver and gut of zebrafish. A research undertaken by Lusher *et al*. (2013) which examined microplastics in 10 species of fish from the English Channel, with a total of 504 fish being tested, found to have 36.5% plastic in the gastrointestinal tract. Both five pelagic species and five demersal species have been found to ingest plastics. In Paris, a series of microplastic particles also found in the liver of freshwater fish (Collard *et al*., 2018).

Microplastics have been evidently seen in the digestive tracts of Gobio gobio (Gudgeon fish) from seven locations of the French rivers, such as Jouanne (JOU), Risle (RIS), Bedat (BED), Loire (LOV), Loire (LOI), Chée (CHE) and Hers-mort (HER), with contamination between 11 and 26%. The plastic type and composition found in the gastrointestinal tract are hard and colored fibres and translucent fibers and pellets (Sanchez *et al*., 2014). It has been identified that there is a microplastic presence in the digestive tract (intestine and stomach) of the European flounder (*Platichthys flesus*) from Erith (riverine site 1) which is a plastic and fiber fragment in 90% of fish. 71% of European flounder fish from the Isle of Sheppey have been found to have ingested plastic. Although the European flounder from Erith (river site 2) ingested 38 debris in 83% of the specimens. 20% of the European smelting (*Osmerus eperlanus*) taken from Erith is ingested in plastic (McGoran *et al*., 2017) (Table 1).

Table 1: Lists of fish species and the ingestion % in gastrointestinal track

Fish Species	Country/Area	Sample (N)	Fish with plastics	% Ingestion	Gastrointestinal Tract	References
Alosa fallax	Coast of Portugal	1	1	100	Stomach	Neves *et al*. (2015)
Amberstripe scad Decapterus muroadsi (Carangidae)	Coast of Rapa Nui (Easter Island)	20	16	80	Gut	Ory *et al*. (2017)
Arctozenus risso	North Atlantic	-	14	21	Digestive tracts/ oesophagus	Lusher *et al*. (2016)
Benthosema glaciale	North Atlantic	-	27	22	Digestive tracts/ oesophagus	Lusher *et al*. (2016)
Boops boops	- Balearic Sea -Coast of Portugal	337 32	288 3	68 9	- Full gastrointestinal tracts -Stomach	Nadal *et al*. (2016); Neves *et al*. (2015)

Table 1 (continued):

Fish Species	Country/Area	Sample (N)	Fish with plastics	% Ingestion	Gastrointestinal Tract	References
Chelidonichthys lucernus	Adriatic Sea	3	2	67	Stomach	Avio *et al.* (2015)
Cod	Baltic Sea	74	1	1.4	Full gastrointestinal tracts	Rummel *et al.* (2016)
Dab (Flatfish)	North Sea	74	4	5.4	Full gastrointestinal tracts	Rummel *et al.* (2016)
Dicentrarchus labrax	Mondego estuary	40	9	23	gastrointestinal tract	Bessa *et al.* (2018)
Diplodus vulgaris	Mondego estuary	40	29	73	gastrointestinal tract	Bessa *et al.* (2018)
Flounder	Baltic Sea	20	2	10	Full gastrointestinal tracts	Rummel *et al.* (2016)
Japanese anchovy (Engraulis japonicus)	Tokyo Bay	64	49	77	Digestive tracts	Tanaka & Takada (2016)
Lepidorhombus boscii	Coast of Portugal	2	1	50	Stomach	Neves *et al.* (2015)
Mackerel	- Baltic Sea - North Sea	13 38	4 5	30.8 13.2	Full gastrointestinal tracts	Rummel *et al.* (2016)
Maurolicus muelleri	North Atlantic	-	282	2.8	Digestive tracts/ oesophagus	Lusher *et al.* (2016)
Merluccius merluccius (Hakes)	Gulf of Cádiz	12	2	16.7	Stomach	Bellas *et al.* (2016)
Merluccius merluccius (European hake)	Coast of Portugal	7	2	29	Stomach	Neves *et al.* (2015)
***Merlucius merlucius* (bentho-pelagic)**	Adriatic Sea	3	3	100	Stomach	Avio *et al.* (2015)
Mullus barbatus	Adriatic Sea	11	7	64	Stomach	Avio *et al.* (2015)
Mullus barbatus (Red Mullets)	Mediterranean coast (Barcelona, Cartagena, Málaga, Mahón, Ciutadella)	128	24	18.8	Stomach	Bellas *et al.* (2016)
Mullus surmuletus	Coast of Portugal	1	1	100	Stomach	Neves *et al.* (2015)
Nemichthys scolopaceus	North Atlantic	1	1	100	Digestive tracts/ oesophagus	Lusher *et al.* (2016)
Notoscopelus kroyeri	North Atlantic	-	417	14.6	Digestive tracts/ oesophagus	Lusher *et al.* (2016)

Table 1(continued):

Fish Species	Country/Area	Sample (N)	Fish with plastics	% Ingestion	Gastrointestinal Tract	References
Pagellus acarne	Coast of Portugal	1	1	100	Stomach	Neves *et al*. (2015)
Platichthys flesus	Mondego estuary	40	5	13	gastrointestinal tract	Bessa *et al*. (2018)
Sardina pilchardus	Adriatic Sea	99	19	19	Stomach	Avio *et al*. (2015)
Scomber japonicus (Chub mackerel)	Coast of Portugal	35	11	31	Stomach	Neves *et al*. (2015)
Scomber scombrus (Atlantic mackerel)	Coast of Portugal	13	4	31	Stomach	Neves *et al*. (2015)
Scyliorhinus canicula (Dog Fish)	-Galician coast -Cantabrian coast -Gulf of Cádiz	72	11	15.3	Stomach	Bellas *et al*. (2016)
Scyliorhinus canicula (small-spotted catshark)	Coast of Portugal	17	2	12	Stomach	Neves *et al*. (2015)
Squalus acanthias	Adriatic Sea	9	4	44	Stomach	Avio *et al*. (2015)
Stomias boa boa	North Atlantic	-	5	40	Digestive tracts/ oesophagus	Lusher *et al*. (2016)
Trachurus picturatus (blue jack mackerel)	Coast of Portugal	29	1	3	Stomach	Neves *et al*. (2015)
Trachurus trachurus (Atlantic horse mackerel)	Coast of Portugal	44	3	7	Stomach	Neves *et al*. (2015)
Trigla lyra (piper gurnard)	Coast of Portugal	31	6	19	Stomach	Neves *et al*. (2015)
Xenodermichthys copei	North Atlantic	-	5	60	Digestive tracts/ oesophagus	Lusher *et al*. (2016)
Zeus faber	Coast of Portugal	1	1	100	Stomach	Neves *et al*. (2015)

Ecotoxicological effects of microplastics and nanoplastics on humans and fish

Pigment of plastic waste contains various toxic elements (Gondal and Siddiqui, 2007). The release of toxic chemicals in plastic waste and then absorbed into the soil causing the groundwater to be contaminated (North and Halden, 2013). Hurley and Nizzetto (2018) further supports the argument that microplastics that have entered the soil can be retained in storage, then translocated, eroded, deteriorated and washed into groundwater. In the end of the process may threatening the organism as well as human health. While, microplastics can absorb toxic chemicals from the ambient seawater that can be transmitted to the food chain (Reiser *et al*., 2014). So, the ingestion of microplastics by organisms brings a significant risk, such as oxidative stress, pathological stress, reduced growth rate, reproductive complications, false satiation, and blocked production of enzymes (Fossi *et al*., 2016; Sutton *et al*., 2016). Studies have also shown that microplastics are very harmful and can have detrimental impacts on organisms (feed disruption, reproductive reduction, intestinal damage and energy metabolism disruptions) and many more (Anbumani and Kakkar, 2018; Zhu *et al*., 2018; Lei *et al*., 2018a; Lei *et al*., 2018b).

Microplastics can be a carrier of hydrophobic pollutants, since plastics are made of highly hydrophobic materials with chemical contaminants found in or on the surface of plastics, as well as microplastics functioning as reservoirs of toxic chemicals in the environment (Cole *et al*., 2011). Studies performed using virgin polyethylene pellets on four beaches along the coast South of Devon, SW England and detected the presence of heavy metals such as aluminum (Al), iron (Fe), manganese (Mn), copper (Cu), lead (Pb), zinc (Zn), silver (Ag) was absorbed from seawater (Ashton *et al*., 2010). Microplastics deteriorate very slowly and can stay in the environment for a long time (Beaumont *et al*., 2019). With all of these plastics may contain several types of additives including plasticisers, stabilizers, flame retardants, pigments and antimicrobials (Teuten *et al*., 2009; Andrady, 2015). The physico-chemical properties of microplastics also affect the toxicological effects on marine organisms (Wright *et al*., 2013) and mostly plastics include polyethylene (PE), polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC) and polyethylene terephthalate (PET) (Geyer *et al*., 2017).

These microplastics and nanoplastics often threaten human health, such as gastrointestinal toxicity, liver toxicity, reproductive toxicity, neurotoxicity and joint toxicity. This toxins are caused by ingested contaminants, which mechanisms can be involved in oxidative stress, inflammatory reactions and metabolic disorders. Oral ingestion is the primary route of human exposure to microplastics and nanoplastics as well as by inhalation and exposure to the skin (Chang *et al*., 2020). Microplastics have been detected in table salt, beer, seafood, honey, sugar and even drinking water and other foods (Yang *et al*., 2015; Horton *et al*., 2017; Pivokonsky *et al*., 2018; Waring *et al*., 2018) could be one of the oral intake by human and this may led to increasing toxinity in human body. Karami *et al*. (2017), were revealed in a report that found that microplastics>149 μm of 17 salt brands in eight countries were correlated with health risks. The study also found that 41.6% of plastic polymer, pigment (23.6%), amorphous carbon (5.50%), and unknown (29.1%) contain in the salt. The most common plastic polymers are polypropylene (40.0%) and polyethylene (33.3%). While, fragments are the predominant type of Microplastics which 63.8%, filaments (25.6%) and films (10.6%) (Karami *et al*., 2017).

There are some potential toxicity of microplastics on human health. Study by Jin *et al*. (2018) found that polystyrene microplastics in Adult male zebrafish can cause increased mRNA levels of IL1α, IL1β, IFN and protein levels in the gut indicating that inflammation occurred after polystyrene microplastics exposure then will lead to human gastrointestinal toxicity. Polyamide, polyethylene, polypropylene, polystyrene, and polyvinyl chloride found in the intestine of zebrafish Danio rerio and nematode Caenorhabditis elegans have caused villi cracking and splitting of enterocytes in the animal and potential for human gastrointestinal toxicity (Lei *et al*., 2018a). The microplastic accumulation of polystyrene in the liver and intestines of Zebrafish has the potential to cause liver toxicity in humans (Lu *et al*., 2016). Lu *et al*. (2016) have also found that the accumulation of polystyrene can cause inflammation and lipid accumulation both in 5 μm and 70 nm, oxidative stress and alterations in their metabolic profiles as well as disturbance of lipid and energy metabolism. This matter needs to be taken into consideration because more than 20% of the food consumption by 1.4 billion people which are representing 19% of the global population, is seafood (Golden *et al*., 2016).

Exposed to microplastics in water and food can affect the hatching performance of fish eggs (Lönnstedt and Eklöv, 2016) and result in histopathological alteration of the intestinal and hepatic tissues of fish (Lu *et al*., 2016; Pedà *et al*., 2016). Microplastics can induce liver stress (Lu *et al*., 2016), distal bowel changes (Pedà *et al*., 2016) and minimize individual predator reaction (Ferreira *et al*., 2016), physical retention of MPs in digestive tracts (Lu *et al*., 2016) and chemical leaching of plastic additives into tissues (Karami *et al*., 2016) (Fig. 7).

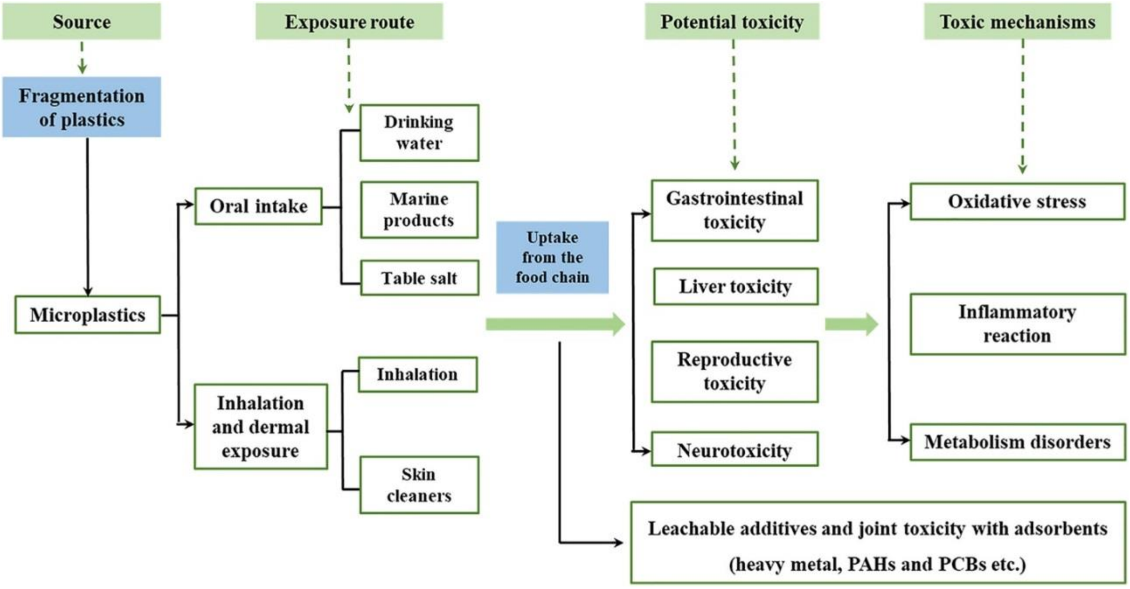

Figure 7: Potential toxicity and toxic mechanism caused by oral intake of microplastics and nanoplastics (Chang *et al*., 2020)

Conclusion

Microplastic and nanoplastic contaminants have been shown to occur in a multitude of ecosystems and a significant number of species in the marine/freshwater/aquatic environment such as fish. As a consequence, bioaccumulation, and biomagnification of microplastic and nanoplastics, toxins and chemicals, is frequently inferred in seafood nets. The high availability of bio-microplastics and nanoplastics in marine environments especially in fish has raised serious concerns over the past few decades. Therefore, it is important to know how toxicity in fish consumed by higher trophics can affect their health as well as the fish itself. Most studies have been done to look at the content of microplastics or nanoplastics in the fish gastrointestinal tract.

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