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Microplastic In Inland Water Fish In India: Presence And Fate

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Abstract

The present study on microplastics deals with the reports on pollution and its toxicity in the context of fish health. The over use of plastics and microplastics has not only threatened our natural environment but also contaminations of microplastics residues have been detected in fishes. The occurrence of microplastics and their potential impacts in the fish health gain special attention because fish is an important link in the food web. This chapter presents the current knowledge about bioaccumulation of microplastics in different tissue of fresh water fish and their toxic impact on Neurotoxicity, Oxidative stress and Hematological changes in fish. Fish suffered from various health problems after exposure to microplastics alone or in combination with other pollutants. Hopefully, this chapter could extend the current knowledge on the toxicological impacts of microplastics contamination to fish and provide guidance for future research.

Keywords: Microplastics, contamination, toxicological impacts, health risk, fish, water etc.

Introduction

Microplastics (MPs) are synthetic polymers particle or debris of plastics which is widely used in everyday life (Rao, 2019) whose diameters less than 5mm with size range between 0.1 to 5000 μm (Thompson et al., 2009, EFSA, 2016, J. Ding et al., 2018). On the basis of production of MPs are classified into primary and secondary MPs (Li et al., 2018). Primary MPs are small plastic particles produced directly in factories and are used in medicines, synthetic microfibers in textiles, and personal care products (as scrubbing agents in cosmetics in face wash), air blasting pellets etc. (Barnes et al., 2009) released directly in water and can be transported into the aquatic environment (Cole et al., 2011; Gall and Thompson, 2015). Secondary microplastics formed due to progressive physical, chemical and photo degradation of large plastic debris such as fishing nets, discarded household plastic items, resin materials as well as disposable plastic materials (Singh and Sharma, 2008; Eerkes- Medrano et al., 2015), plastic bottles etc. (Boucher and Friot, 2017) present in the ecosystem (Arthur et al., 2009).

The increasing demands of plastic results intensely enhanced yearly production from 1.5 million tonnes in the 1950s and reached up to 350 million tonnes in 2017 (Plastics Europe 2018). India contributes around 0.09 to 0.24 million metric tonnes per year (Jambeck et. al., 2015). Microplastics are of different types of polymer include polyethylene, polypropylene, polystyrene, polyester, and polyvinyl chloride, which correspond with the mass production and extensive usage of these polymers all over the world (Horton et al 2017).

Microplastics distributed ubiquitously, has been reported in marine environment worldwide (W. Wang, et al. 2019), along coasts (Veerasingam et al., 2016), in the waters and sediments of freshwater environments (Baldwin et al., 2016; Horton et al., 2017a, 2017b; Zhang et al., 2017), drinking water samples from New Delhi (Kosuth et al., 2017), in invertebrates (Su et al., 2018), in fish intestines in Kerela (Kripa et al., 2014) and the gut contents of freshwater fish (Jabeen et al., 2017; Zhang et al., 2017).

Microplastics are readily ingested or consumed by invertebrates and fish (Tanaka and Takada, 2016), intentionally or non-intentionally due to their small size and resemblance with planktons (Crawford and Quinn 2017). Ingestion of microplastics cannot cause only physical effects to fish (e.g., mechanical damage and digestive tract blockage), but also provide a potential pathway for introduction of some hazardous substances (e.g., plastic additives, toxic chemicals, pathogenic microorganisms colonizing on the plastics) causing suffocation and even the death of fish (Gregory, 2009; Wright and Kelly 2017). This issue raises concerns about the ecological and fish health impacts of MPs and enters in food-chains ultimately impacts on human health (Duis and Coors, 2016).

Thus, the aim of this chapter is to: 1) describe the presence of microplastics in Indian waters, 2) highlight the microplastics ingestion by fish in both the field and laboratory scenarios, 3) evaluate the toxicological effects of microplastics on fish health. By collating literatures, we present out the current knowledge gaps, create database for the welfare of mankind and propose several perspectives for future research.

1. Presence of microplastics in Indian water

The fragments of microplastics in water are present in the form of plastic fibers and fragments, which are mainly generated by fragmentation of large plastic debris and these suggests that the occurrence of microplastics in aquatic environments originates primarily from secondary sources (Dai et al., 2018; Zhang et al., 2018).

Plastic items formed 97% by weight and 99% by number of the total marine litter in the stake net fisheries of Vembanad Lake, Kerala (Shylaja et al., 2018) and the average weight of plastic covers in the nets was 985 g net-1 day-1. Analysis of beach debris collected from 254 beaches in India depicts a synoptic picture of beach debris (Kaladhran et al. 2017). The plastic items in the litter is of nylon nets/ fishing lines, single use carry bags, edible oils, detergents, sachets of soft drinks, beverages, toothpaste, PET bottles cases of cosmetics, and ice cream containers etc. and the quantity of plastics in beach litter ranged between 0.08 g m-2 (Odisha coast) and 25.47g m-2 (Goa coast) (Kaladhran et al. 2017). Significantly, the archipelagic coasts of Andamans (47%) and Lakshadweep (40%) recorded higher proportion of plastic in the beach litter compared to the national average of 14%. However, the percentage occurrence of microplastics of size 50 μm to 5 mm in marine debris is less than 5% (Kripa, 2018). Polyethylene and polypropylene were the dominant polymers in microplastics reported in India from beach litter (Veerasingam et al., 2016) and sediment samples from Vembanad Lake (Sruthy and Ramasamy, 2017).

Ingestion of microplastics by fish in natural environments

In India, plastic ingestion was reported in different marine fish such as sardine, mackerel, anchovy, ribbon fishes, dolphin-fish, tunas and several other fishes caught from almost all states along the south-west and south-east coasts (Sulochanan et al., 2011; Sajikumar et al., 2013; Kripa et al., 2014; Kripa, 2018). Ingestion of microplastics by fish species is evidenced by the analysis of contents in the gastrointestinal tracts of fish. Fishes of many species are contaminated with microplastics and occupy a large variety of aquatic habitats. Microplastics detected in fish exhibit considerable differences in color, shape, and polymer type.

Microplastics were widely recorded in the stomachs of black mouth cat shark (Galeus melastomus) (Alomar and Deudero, 2017). Microplastics are retained in the digestive systems of fish, including the stomach and intestine after ingestion (Wright and Kelly, 2017). Microplastics adhere to the skin of fish and it also translocate to other tissues, such as gills, liver, and muscle (Abbasi et al., 2018; Su et al., 2018). Microplastics could translocate into the circulatory or lymphatic system, resulting in dispersion of microplastics throughout the whole body (Wright and Kelly, 2017). Unfortunately, data is limited regarding presence of microplastics in tissues of fish outside digestive tract.

3. Toxicological effects of microplastics on fish

Microplastics accumulated in gastrointestinal tracts of fish after ingestion, causing blockages throughout the digestive system and reduced feeding due to gut fullness (Lusher et al., 2013; Wright et al., 2013), lead to structural and functional deteriorations in the gastrointestinal tracts, which in turn would cause nutritional and growth problems to fish (Peda et al., 2016; Jabeen et al., 2018). In a study with Jacopever (Sebastes schlegelii), Yin et al. (2018) reported that the fish after exposure to 106 particles/L of polystyrene microplastics, the weight gain rate, specific growth rate, and gross energy were decreased by 65.4%, 65.9%, and 9.5% respectively relative to the control. Ingestion of microplastics could also induce inflammatory responses in fish (Lu et al., 2016), change the metabolic profiles (Mattsson et al., 2014), and disturb the immune system of fish (Greven et al., 2016). Microplastics are able to translocate to other organs of fish, such as the liver and gills, and cause damage in these organs (Yin et al., 2018). The laboratory studies depict the toxicological impacts of microplastics exposure on fish.

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Jiannan Ding et al., 2018 reported that the microplastic inhibit the acetyl cholinesterase (AChE) activity in the fish brain, antioxidative enzyme superoxide dismutase (SOD) in the liver was significantly increases in *Oreochromis niloticus*. Microplastics (MPs) ingested by marine organisms causes blockage of the gastrointestinal tract or inflammatory responses and consequently trigger a range of adverse effects, such as lower energy reserves, reduced reproduction / growth, oxidative damage, metabolism disruption, and cellular lesions (Eerkes- Medrano et al 2015, Horton et al 2017a). Rochman et, al., 2013 reported that exposure to polyethylene microplastics induced hepatic stress in Japanese medaka (*Oryzias latipes*), including glycogen depletion, fatty vacuolization and cell necrosis and bioaccumulation of polyethylene microplastics can disturb lipid and energy metabolism as well as induce oxidative stress in the liver of zebrafish (*Danio rerio*). The activities of antioxidant enzymes and glutathione s-transferase and the levels of reduced glutathione progressively, the activity of the pro inflammatory enzyme, myeloperoxidase, and the levels of oxidative damage markers malondialdehyde and protein carbonyls increases on exposure of diet enriched with MPs. (Antonia et al 2020). Microplastics ingestion or gill infiltration result in several negative effects including inflammation, metabolic disorders, neurotoxicity, hepatic stress, growth and behavior alterations, obstruction of gastrointestinal tract, blockage of feeding appendages or generate pseudo-satiation leading to reduced food intake (Wright et al 2013,Rochman et

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al 2014,Li et al 2016,Barboza et al 2018a)

The toxicity of MPs is characterized by the generation of reactive oxygen species (ROS), like superoxide anion (O2-), hydrogen peroxide (H2O2) and hydroxyl (OH-), peroxyl (RO2-), and alkoxyl (RO.) radicals which induce the oxidation of lipid, protein and DNA and other cellular component (AshaRani et al 2009, Mahmoudi et al 2011).

Hamed et al., 2019 reported that in Nile Tilapia (Oreochromis niloticus), the biochemical parameters (creatinine, uric acid, AST, ALT, ALP, glucose, cholesterol, total protein, albumin, globulin, and A/G ratio) significantly increases, the hematological indices like RBC's count, Hb, Ht (hematocrit), MCHC, Platelets, WBC's count, and monocytes significantly decreases while MCV and MCH significantly increase on exposure to microplastics.

Iheanacho and Odo 2020 reported that PVC microplastics cause alterations in hematological indices, mean cell volume and mean cell hemoglobin values reduced significantly, neutrophil counts decreased, glutathione peroxidase activity altered significantly in the brain and gill, superoxide dismutase activity was inhibited in the brain and gill, catalase activity reduced significantly in the brain, lipid peroxidation levels in the brain increases significantly in a dose and time-dependent manner. Acetylcholinesterase activity in the brain and gill increases significantly on the exposure of PVC microplastics.

Conclusions

Microplastics are a class of environmental contaminants of emerging concern because microplastic distributed in almost all types of aquatic habitats in the world. Due to the continuous emission of plastic waste into the environment, the number of microplastics will continue to increase in waters that makes available to fish populations. Evidence suggests that fish ingested microplastics and after ingestion, microplastics can accumulate in the gastrointestinal tracts of fish and are able to translocate to other organs. Exposure to microplastics can induce various health problems to fish. Microplastics may transmit hazardous chemicals and pathogenic microorganisms to fish. Laboratory based exposure studies have played a leading role in elucidating the toxicological effects of microplastics on fish.

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