A seminar paper on

Micro-plastics pollution and its effects on aquatic organisms

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Submitted to:

Course Instructors	Major Professor
1. Dr. A. K. M. Aminul Islam Professor, Dept. of Genetics and Plant Breeding 2. Dr. Md. Mizanur Rahman Professor, Dept. of Soil Science 3. Dr. Md. Sanaullah Biswas Associate Professor, Dept. of Horticulture 4. Dr. Dinesh Chandra Shaha Associate Professor, Dept. of Fisheries Management	Dr. Md. Jahangir Alam Professor Department of Fisheries Biology & Aquatic Environment

Submitted by:

Mahmudul Hasan Mithun

MS Student

Reg. No.: 15-05-3622

Department of Fisheries Biology & Aquatic Environment

BANGABANDHU SHEIKH MUJIBUR RAHMAN AGRICULTURAL UNIVERSITY

SALNA, GAZIPUR 1706

Abstract

Micro-plastics (MPs) are small in size and society has become increasingly reliant on plastics since commercial production began in about 1950. Their versatility, stability, light weight, and low production costs have fueled global demand.. In 2020, the total plastic production reached 400 MT where 60 years ago its production was only 1.5 MT and it is believed by the scientists that it will likely to reach 33 billion tons by 2050. As a new type of pollutant, micro-plastics are an emerging scientific and social concern in the environment and are widely distributed in the aquatic environment and organism. Long-term exposure to MPs results in eco-toxicity to the aquatic organisms like mortality, genotoxicity, neurotoxicity, reproductive problems, oxidative stress, and so on. MPs not only deliver chemical substances within organisms, but also act as mediators for chemicals or other contaminants in aquatic environments. Co-exposure to MPs and chemical contaminants has been reported to increase toxicity in several organisms. As aquatic organisms are the important part of food web and ecosystem, the ultimate exposure of MPs occur in human via aquatic organisms. This review paper provides a critical perspective on published studies of MP ingestion by aquatic biota. Summarization of the present global plastic situation, routes of MPs in the environment to aquatic organisms and human, eco-toxicological effect of MPs to aquatic organisms, interaction of MPs to other contaminants in the environment and their subsequent effects on aquatic organisms and finally the MPs pollution in Bangladesh are provided in this review paper.

Keywords: Micro-plastics, routes of MPs, eco-toxicology, aquatic organisms, human exposure, pollution in Bangladesh.

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Chapter 01

Introduction

1.1. General background

Micro-plastics (MPs) are very small pieces of plastic that pollute the environment. According to the U.S. National Oceanic and Atmospheric Administration (NOAA) The term "micro-plastic" refers to plastic particles that are <5 mm in size . The presence of small plastic pieces in the oceans was first noted by scientists in the early 1970s. Since that time, many scientists have studied the potential problems associated with what we now term "micro-plastics." Micro-plastic debris in aquatic ecosystems is currently considered one of the most important global pollution problems of our time. Micro-plastics can be classified as primary or secondary, depending on the manner in which they are produced. Primary MPs are small plastic particles released directly into the environment via e.g. domestic and industrial effluents, spills and sewage discharge or indirectly (e.g. via run-off). Primary micro-plastics particles are intentionally manufactured in sizes <5 mm for use in personal care products or industrial applications. Plastic micro beads have become common components in consumer products such as toothpastes, body washes, and facial cleansers. Secondary MPs are formed as a result of gradual degradation/fragmentation of larger plastic particles already present in the environment, due to e.g. UV radiation (photo-oxidation), mechanical transformation (e.g. wave's abrasion) and biological degradation by microorganisms (Cole *et al.,* 2011). Micro-plastics in the environment can be further degraded/ fragmented to produce nano-plastics (1–100 nm), which, when compared to other forms of plastic litter, have largely unknown fates and toxicological properties (da Costa *et al.,* 2016). However, secondary micro-plastics are considered to be the largest source of micro-plastic pollution in aquatic environments (Eriksen *et al.,* 2013) and their abundance will increase enormously with the continuous input of plastic debris from different origins. MPs are found in a wide range of shapes (e.g. spheres, fibre, film, irregular) and densities. For that why they disperse diversely in different compartments of the aquatic environment (water surface, water column and sediment) and influence their availability to organisms at different trophic levels which causes severe toxicity both aquatic organisms and the aquatic ecosystem.

1.2. Rationale

The material characteristics of plastics, especially their light weight, durability, and corrosion resistance, account for their widespread use in industry and in daily life. The plastic industry has grown enormously since 1950 such that global plastics production reached 320 million tons in 2017 (Plastics Europe, 2018) and will likely reach 33 billion tons by 2050 (Rochman *et al.,* 2013). However, the extensive use, high-level production, rapid disposal, and recalcitrance to degradation of plastics have resulted in their large-scale release into aquatic and terrestrial environments, where they will persist for centuries. Rivers transport 70–80% of plastics, leading to their extensive deposition in the world's oceans (Horton *et al.,* 2017). Moreover, because of their small size and large specific surface area, micro-plastics are bioavailable to a wide range of aquatic organisms and may therefore induce toxic effects whose impacts may spread throughout the food chain. Among the aquatic organisms known to ingest micro-plastics are amphipods, copepods, lugworms, barnacles, mussels, decapod crustaceans, seabirds, fish, and turtles (Abbasi *et al.*, 2018). Toxic effects on growth, reproduction, and survival have been demonstrated, together with oxidative stress and neurotoxicity (Wang *et al.*, 2019c). As one of the fastest-growing sources of pollution, plastic debris has become an environmental concern of high priority.

1.3. Objectives

Based on above facts the objectives of this review paper are-

1. To analyze the current global plastic situation and the types of micro-plastics those are highly studied and reported in the aquatic organisms.
2. To assess the routes of micro-plastics and their eco toxicological effects on aquatic organisms as well as human.
3. To evaluate the condition of micro-plastics pollution in Bangladesh.

Chapter 2

Materials and methods

This seminar paper is exclusively a review paper. All the information has been collected from the secondary sources. During the preparation of the review paper, I went through various books, journals, proceedings, reports, publications, internet etc. relevant to this topic. I got suggestions and valuable information from my major professor and my course instructors. After collecting all the available information, I myself compiled that collected information, and prepared this seminar paper.

Chapter 3

Review of Findings

3.1. The current global situation of plastic pollution

As per Plastics Europe, global plastics production has increased exponentially from 1.5 million tons in 1950 to 250 million tons in 2010 and almost reached 400 million tons in 2020 (Fig. 01) and it will likely to increase 33 billion tons by 2050 (Rochman *et al.*, 2013).

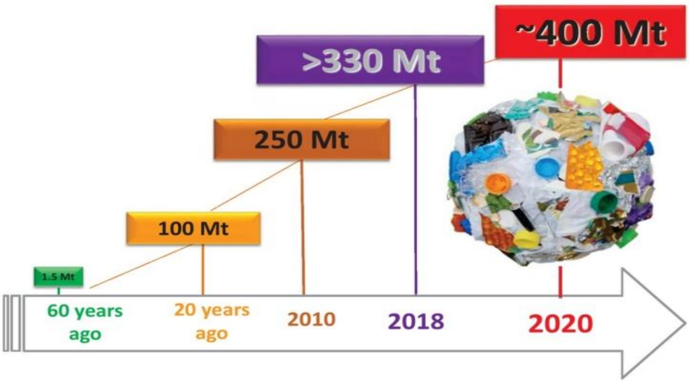

Fig. 01: The rising amounts of global plastic production. (Source: The Euro-Biotech Journal 2, 2; 10.2478/ebtj-2018-0013)

Every year between 1.15-2.41 million tons of plastic flows from the global riverine system into the oceans, of which, the top 20 polluting rivers were identified in Asia that are accounted for more than two thirds (67%) of the global annual input, covering 2.2% of the continental surface area and representing 21% of the global population (Lebreton *et al.*, 2017). It is warned by the scientists that there will be more plastics in the ocean than fish by 2050 unless it's cleaned-up. The major plastic components and their application in the industrial sectors are given in the following Table 01.

Table 1: Major components of plastic waste with their applications

Plastics	Application
Polyethylene terephthalate (PET)	Water and soft drink bottles, food jar
Polyvinyl chloride (PVC)	Cables, plumbing pipes
High density polyethylene (HDPE)	Shampoo bottles, packaging
Low density polyethylene (LDPE)	Grocery bags, packaging
Polypropylene (PP)	Bottle caps, medicine bottles, chips packs
Polystyrene (PS)	Disposal cups, cutlery, packaging foam
Polycarbonate (PC)	Food packaging, electronic goods, and defense gadgets
Nylon	Fishing nets, clothing, ropes

(Source: Sailaja R.R.N. *et al.*, 2018)

3.2. Types of micro-plastics reported in field and laboratory studies

The most common types of micro-plastics those are reported across field and laboratory studies include PE (23%) and PS (22%), followed by PP (12%) and PES (9%) (Fig.02). Fish were the most commonly studied group of organisms (44%), followed by crustacean (21% for large and small crustacean combined), molluscs (14%) and annelid worms (6%) (Fig.03). There were relatively few studies of other organism groups.

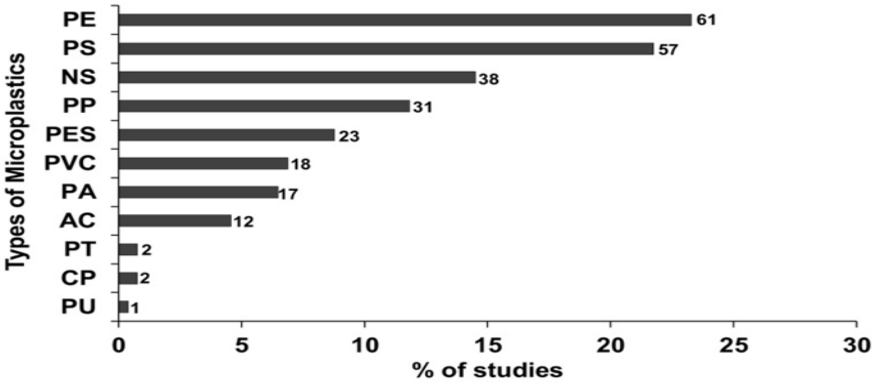

Fig. 02: Percentage of studies of different types of micro-plastics. Every bar has total number of studies. Different types of micro-plastics enumerated include PE-Polyethylene; PS-Polystyrene; NS-Not specified; PP-Polypropylene; PES-Polyester; PVC-Polyvinylchloride; PA-Polyamide; AC-Acrylic; PT-Polyether; CP-Cellophane; PU-Polyurethane. (Source: de Sá LC *et al.,* 2018)

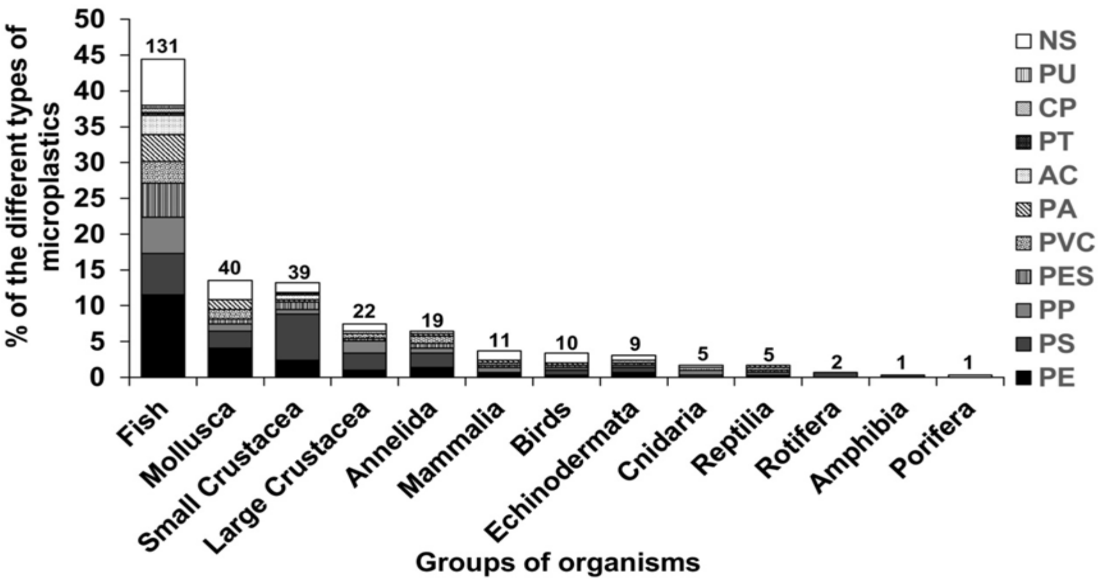

Fig. 03: Percentage of the different type of micro-plastics per group of organisms. Every bar has the total number of studies. Studies were defined according the typology of micro-plastics and the number of individuals per group of organisms. Plastic types enumerated include NS-Not specified; PU-Polyurethane; CP-Cellophane; PT- Polyether; AC-Acrylic; PA-Polyamide; PVC-Polyvinylchloride; PES-Polyester; PP-Polypropylene; PS-Polystyrene; PE-Polyethylene. (Source: de Sá LC *et al.*, 2018)

Polyethylene was the most common type of MP studied in fishes; it was about 12% of the total number of studies identified. Ingestion of PE by fish is both widespread and crosses habitat preferences. For example, it has been showed that over one third of fish examined in their study had ingested MPs, with pelagic and benthic fish displaying similar gut contents, suggesting either a lack of selectivity or widespread presence of PE in both the water column and sediments (Lusher *et al.*, 2013). The presence of PE was reported less commonly in other groups of organisms like mollusks, small crustaceans and annelids (Fig.03). There were relatively few studies of PE in vertebrates other than fish (Fig.03).

Effects of PS MPs have been reported in studies of fish and small crustaceans (Fig. 03). Although crustaceans have been shown to have the ability to distinguish live particles from inert ones, e.g. algae and PS beads (Poulet and Marsot, 1978), ingestion of PS MPs has been observed in small crustaceans occupying both pelagic and benthic environments. It has been reported that dead copepods can have adhered PS fragments, which could contribute to the vertical transport of this type of MP (Cole *et al.*, 2013). The widespread distribution of MPs in aquatic ecosystems (Lusher *et al.*, 2013) and broad range of physicochemical properties makes a wide range of aquatic organisms potentially susceptible to these emerging contaminants. There are a number of ways in which organisms may accumulate MPs. Animals exposed to MPs may incorporate them through their gills (Watts *et al.*, 2014) and digestive tract (de Sá *et al.*, 2015). The ingestion may be due to an inability to differentiate MPs from prey (de Sá *et al.*, 2015) or ingestion of organisms of lower trophic levels containing these particles (e.g. plankton containing MPs) (Fendall and Sewell, 2009). MPs may also adhere directly to organisms (Cole *et al.*, 2013).

3.3. Routes of micro-plastics to aquatic organisms

Absorption and ingestion of micro-plastics by organisms from the primary trophic level, e.g. phytoplankton and zooplankton, could be a pathway into the food chain (Bhattacharya *et al*., 2010). Many species of zooplankton undergo a diurnal migration. Migrating zooplankton could be considered a vector of micro-plastic contamination to greater depths of the water column and its inhabitants, either through predation or the production of faecal pellets sinking to the seafloor (Wright *et al.*, 2013a). Field observation highlighted the presence of micro-plastics in the scat of fur seals (*Arctocephalus spp.*)(Eriksson and Burton, 2003). In feeding experiments, micro-plastic were identified in the gut and haemolymph of the shore crab (*Carcinus maenas*) (Farrell and Nelson, 2013). Micro-plastics were also detected in cod, whiting, haddock, bivalves and brown shrimp, which are consumed by humans and raises concerns about trophic transfer to humans and human exposure (Galloway, 2015). Micro-plastic interactions in the marine environment and their trophic transfer are shown in the following (Fig. 04).

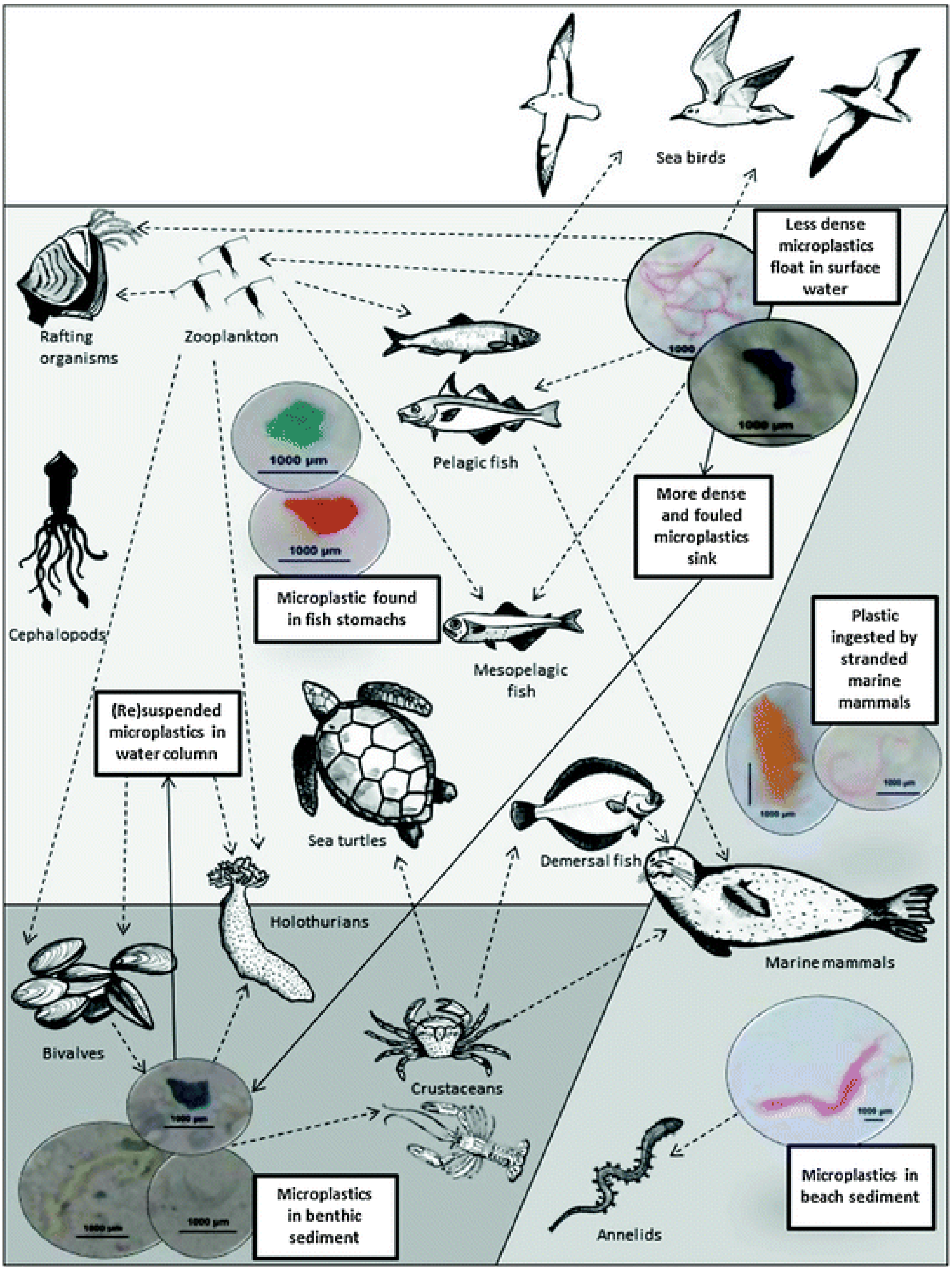

Fig. 04: Micro-plastic interactions in the marine environment including environmental links (solid arrows) and biological links (broken arrows), which highlights potential trophic transfer (Source: Lusher *et al.*, 2013)

3.4. Eco-toxicological effects of MPs on aquatic organisms

A total of 130 studies reporting eco-toxicological effects of MPs on aquatic organisms were identified (Fig. 05). Crustaceans were the most commonly studied taxonomic group, followed by fish, molluscs , annelid worms, echinoderms and rotifers. These organism groups occupy a number of positions in aquatic food webs. Fish are generally intermediate/top predators (de Sá *et al.,* 2015) and may ingest MPs either directly or through consumption of prey containing MPs. Small crustaceans are often primary consumers as are planktonic rotifers (Desforges *et al.,* 2014). Mollusks include a number of ecologically and commercially important filter feeding organisms. Because of their habitat and feeding behavior, mollusks and other benthic organism groups such as annelid worms are likely to be affected by MPs. Molluscs include a large number of filter feeding species, with a high tendency for bioaccumulation. Considering that several of these organisms are widely used for food (e.g. *Mytilius edulis*), they are a potential source of MPs or environmental contaminants to humans (Van Cauwen berghe and Janssen, 2014). A range of eco-toxicological effects of different MP types have been documented across several groups of organisms (Fig. 05, Table 03).

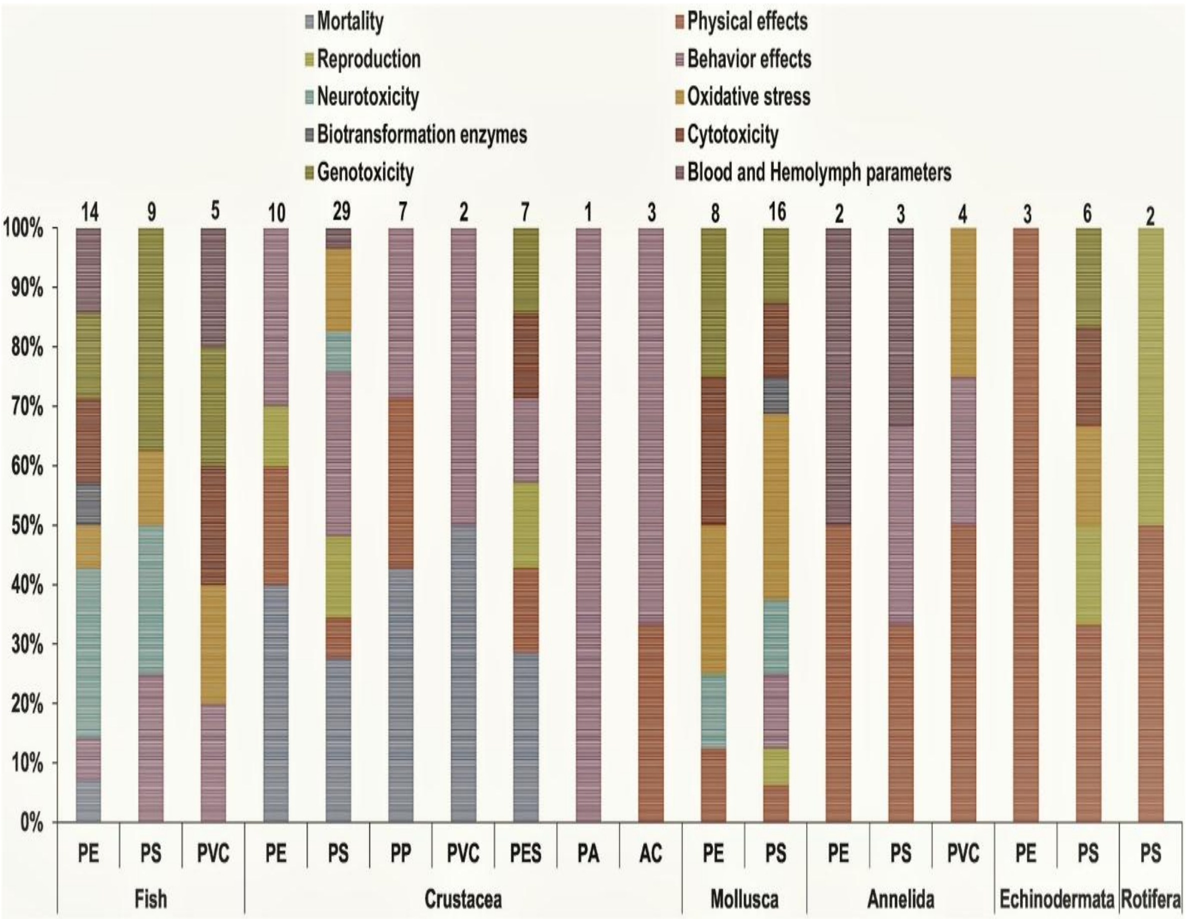

Fig. 05: Eco-toxicological effects of micro-plastics on the different groups of organisms. Every bar has the total number of studies. Studies were defined according to the type of MPs, groups of organisms and effects. (Source: de Sá LC *et al.,* 2018)

Table 02: Eco-toxicological effects of MPs across several groups of organisms

Classes	MPs type	Effects	Ref.
Fish	PE	↓ Total protein, globulin, cholesterol and triglyceride levels ↑ Mortality ↑ CYP P450 ↓ AChE activity ↓ Predatory performance ↓ Predatory efficiency	Oliveira *et al.* 2013; Haghi and Banaee 2017; Mazurais *et al*. 2015; de Sá *et al.* 2015
	PS	↓ Body length ↓ Larval locomotion ↓ AChE activity ↑Alterations of metabolic profiles ↑Lipid and energy metabolism disturbed ↑Inflammations and lipid accumulation in the liver ↓ Activity ↑ Weight loss in the brain ↓ Water in the brain	Chen *et al.* 2017; Lu *et al.* 2016; Mattsson *et al.* 2017
	PVC	↑ Peroxidase activity and skin mucus ↑ Phagocytic capacity ↑ genes related with stress ↑ Structural alterations of the Distal intestine ↓ Regular structure of serosa,	Espinosa *et al*. 2017; Peda *et al*. 2016;
Crustacean	PE	↑ Mortality ↓ Reproduction ↓ Growth	Au *et al*. 2015
	PS	↑ Mortality ↓ Survival ↓ Fecundity ↓ Ingestion rates ↓ Hemolymph sodium ions ↑ Hemolymph calcium ions ↑ Oxygen consumption	Lee *et al*. 2013; Cole *et al.* 2013; Watts *et al.* 2016
	PP	↓ Feeding rate ↓ Body mass ↓ Metabolic rate ↑ Mortality ↓ Growth ↓ Weight	Welden and Cowie 2016; Au *et al.* 2015
	PVC	↑ Mortality ↓ Settlement	Li *et al*. 2016
	PES	↑ Mortality ↓ Settlement ↓ Wet weight gain	Li *et al.* 2016; Jemec *et al.* 2016; Straub *et al.* 2017
	PA	↓ Assimilation efficiency	Blarer and Burkhardt-Holm 2016;
	AC	↑ Immobilization	Booth *et al*. 2016
Mollusks	PE	↑ Energy consumption ↑ MPs accumulation ↓ AChE and Catalase activities ↓ Lysosomal integrity ↓ gene involved in immunity	Van Cauwenberghe et al. 2015; von Moos et al. 2012; Avio *et al.*, 2015; Détrée and Gallardo-Escárate 2017
	PS	↑ Maintenance costs ↓ Oocyte number ↓ Sperm velocity ↓ Filtering activity ↓ Phagocytic activity ↑ Apoptotic processes	Sussarellu *et al.* 2016

Annelida	PE	↑ Energy consumption	Van Cauwenberghe *et al.* 2015
		↓ Protein content	
	PS	↓ Feeding activity	Besseling *et al.* 2013
	PVC	↓ Energy reserves	
		↓ Feeding activity	
		↑ Phagocytic activity	
		↑ Inflammatory response	Browne *et al.* 2013
		↓ Lipid reserves	
		↑ MPs retention	
		↑ Oxidative stress	
Echinoderms	PE	↑ Anomalous larvae development	Nobre *et al.* 2015
	PS	↓ Fertilization rate	
		↓ Growth	
		↑ Larval development abnormalities	
		↑ Oxidative stress	Martinez-Gomez *et al.* 2017;
		↑ MPs accumulation	
		↑ Malformations	
		↑ Disruption of cell membrane	
Rotifers	PS	↓ Growth rate	
		↓ Fecundity	
		↓ Lifespan	Jeong *et al.* 2016
		↑ Reproduction time	

↑=increase, ↓=decrease

3.5. Interactive eco-toxicological effects of MPs with other contaminants

There are a large number of studies on the combined effects of MPs with other environmental contaminants (Fig. 06). These studies are motivated by the situation found in the environment where organisms are simultaneously exposed to several contaminants. The main goal of these studies is to investigate if MPs can interact positively or negatively with the eco toxicological effects of other contaminants.

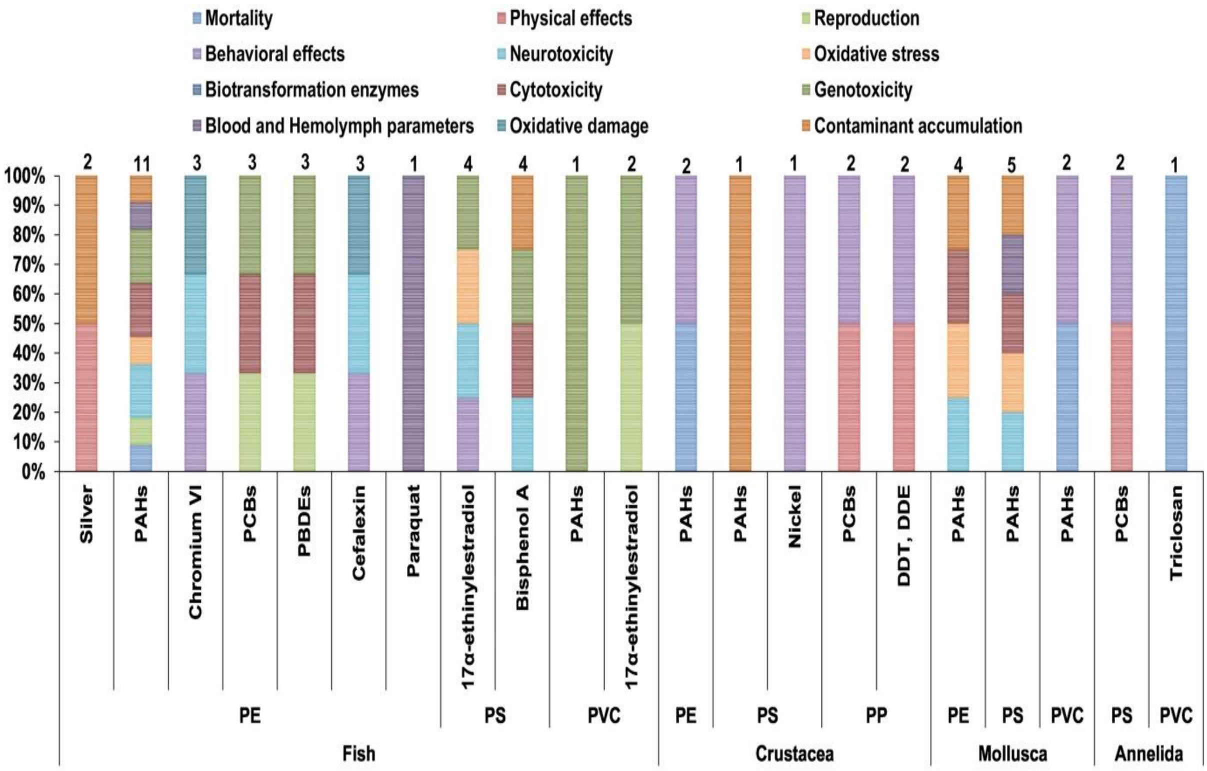

Fig. 06: Combined eco-toxicological effects of MPs with other contaminants on the different groups of organisms. Every bar shows the total number of studies. Studies were defined according to the type of MPs, groups of organisms and effects. (POPs- Persistent organic pollutant; PAHs- Polycyclic aromatic hydrocarbons; PCBs- polychlorinated biphenyls; PBDEs- poly-brominated diphenyl ethers; DDT- dichloro-diphenyl-trichloro-tetra-ethanes; DDE- dichloro-diphenyl-trichloroethanes) (Source: de Sá LC *et al.*, 2018).

Studies examined the combined effects of MPs with legacy Persistent organic pollutant (POPs) (64%), endocrine disrupting compounds (EDCs; 17%), metals (10%), antibiotics (7%) and herbicides (2%). Legacy POPs included PAHs, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and dichlorodiphenyltrichlorotetraethanes (DDT and breakdown products). Metals included silver, chromium VI and nickel. Effects of MPs and the antibiotics celafaxin and triclosan as well as the herbicide paraquat were documented. Endocrine disrupting compounds included the pharmaceutical 17α-ethinylestradiol and Bisphenol-A. Interactions of MPs with other contaminants and their eco-toxicological effects are summarized in the following (Table 3).

Table 3: Interactions of MPs with other contaminants

Classes	MPs type	Contaminants	Effects of the interaction	Ref.
Fish	PE	Silver	↑ Ag accumulation ↑ Oxidative stress	Khan *et al.* 2015
		PAHs,	↑Glycogen depletion in liver ↑Single cell necrosis in liver ↓reduced fecundity ↓anti-estrogenic effect	Rochman *et al.* 2013
		Chromium (VI)	↓ Predatory performance ↓ AChE activity ↑ Lipid oxidation levels	Luis *et al.* 2015
		PCBs, PBDEs	↑Genotoxicity ↑Cytotoxicity ↓reduced fecundity	Rochman *et al.* 2014
		Cefalexin	↓ PEPP ↑ AChE activity ↑ LPO levels	Fonte *et al.* 2016
		Paraquat	↑Biotransformation of enzyme increase ↑ Paraquat toxic effects	Haghi and Banaee 2017
	PS	17α-ethinylestradiol	↓Hypoactivity of the locomotion ↓ Body length (involved in the visual system) (genes involved in the nervous system) ↓ AChE activity	Chen *et al.* 2017a
		Bisphenol A	↑ BPA uptake (involved in the nervous system) ↑ Dopamine contents	Chen *et al.* 2017b
	PVC	PAHs 17α-ethinylestradiol	Oxidative damage ↓(reduced fecundity)	Sleight *et al.* 2017
	PE	PAHs	↑ Mortality ↓ Jumping height	Tosetto *et al.* 2016
	PS	PAHs	↑ Bioaccumulation of Phenanthrene (Contaminant accumulation)	Ma *et al.* 2016
		Nickel	↑ Immobilization (Behavioral effect)	Kim *et al.* 2017
		PCB,DDT,DDE	↑ Energy consumption ↓ Food consumption	Watts *et al.* 2015
	PE	PAHs	↑ Mortalities ↑Oxidative stress ↑ Abnormal embryo ↓ Lysosomal integrity ↓ AChE activity in gills ↑ Nuclear anomalies	Avio *et al.* 2015
Crustacea	PS	PAHs	↑ Hemocyte mortality ↑Oxidative stress ↑Blood and haemolymph parameter imbalance	Paul-Pont *et al.* 2016
Mollusca	PVC	PAHs	↑ Mortality ↓ Filtration rate ↓ Respiration rate	Rist *et al.* 2016
Annelida	PS	PCBs	↓ Feeding activity ↓ Weight ↓ Energy efficiency	Besseling *et al.* 2013
	PVC	Triclosan	↑ Mortality	Browne *et al.* 2013

↑=increase, ↓=decrease

3.6. Routes of Human Exposure

Dietary exposure to plastic is perhaps the most widely recognized route of exposure by the public, even if air pollution is the most prevalent. Dietary exposure occurs through the consumption of shellfish (the most important dietary source) and other seafood and non-seafood such as honey, meat, and salt. Humans even consume tiny plastic particles when we drink water; Orb Media recently demonstrated the presence of plastic in otherwise safe tap and bottled water around the world. While plastic itself is considered inert, there are pathways through which micro-plastics could cause harm to our bodies through inflammation, geno-toxicity, and oxidative stress (Wright, S. L., & Kelly, F. J. (2017).

The presence of plastic nanoparticles was found to cause brain damage and behavioural abnormalities in fish in a 2017 study which marked the first observed cases of direct interactions between plastic nanoparticles and brain tissue (Mattsson, K., *et al.*, 2017). Although the study was carried out on fish, the repercussions of human exposure to plastic particles must be better understood. The smallest of plastic particles may penetrate deeply into organ tissue, and the translocation of plastic particles from the gut to the lymphatic system has furthermore been observed in different species (Brennecke D., *et al.*, 2015). Plastics contain chemical additives which give them various characteristics such as durability, plasticity, and stability in heat. Common among these chemicals are endocrine disrupting chemicals (EDCs). According to the World Health Organization, EDCs are associated with imbalances in sex ratios, disruption in fertility cycles and delayed or accelerated puberty in females, as well as delayed neurodevelopment in children, immune disorders, and hormone-related cancers (Bergman *et al.*, 2013). Even low levels of exposure to endocrine disrupting chemicals are of concern to living organisms; experimental research on animals shows impaired thyroid and immune function, among other concerning side-effects (Gallo, F., *et al.*, 2014).

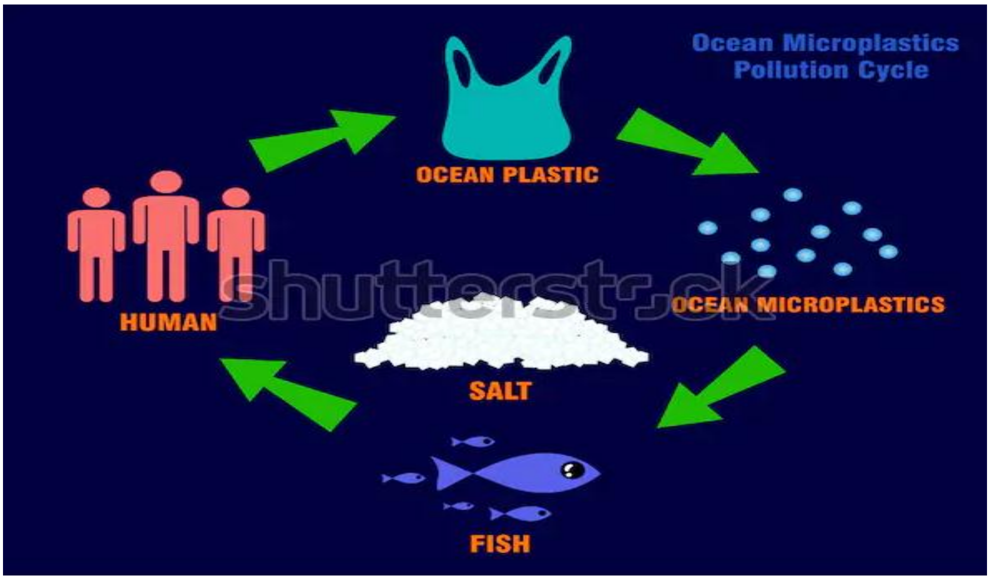

Figure 07: Ocean micro-plastic pollution cycle. (Source: www.shutterstock.com. 1217932783)

3.7. Micro-plastics pollution in Bangladesh

Bangladesh is one of the rising developing countries where consumption of plastic items has expanded than ever before which poses a great threat to the environment and biodiversity. By thinking about the perilous effect of plastic contamination, in 2002, the Bangladesh government banned the assembling, promoting and utilization of polyethylene packs of fewer than 55 µm thickness (Bangladesh Environment Conservation Act No. 1 of 1995). In support of the 2002 ban, the legislature has instituted another law in 2010 for the compulsory use of jute fiber in bundling items rather than polythene bags (Mandatory Jute Packaging Act. (2010). However, at the same time, polythene was continuously produced, traded and utilized all over the country. Statistics showed that plastic waste in the capital city, Dhaka has increased from 1.74% in 1992 to 7.5% in 2019 in overall landfills (Waste Concern. 2019).

Here are some shocking statistics on plastic in Bangladesh (Waste Concern. 2019):

- ✓ 3,000 tonnes of plastic waste is generated every day.
- ✓ Plastic comprises 8% of the total waste generated every year. Numerically, that is 800,000 tonnes.
- ✓ Some 14 million pieces of polythene bags are used every day in Dhaka city. Those often end up in rivers and the ocean, posing a hazard to the sea life.
- ✓ Around 73,000 tonnes of plastic waste end up in the sea every day through the Padma, Jamuna and Meghna rivers.
- ✓ In Old Dhaka alone, around 250 tonnes of non-recyclable products, such as straws and plastic cutlery, are sold every month.
- ✓ The growth in bio waste production is 5.2% while that in plastic waste is 7.5%.

Micro-plastics pollution is a new phenomenon in Bangladesh and manufacturers and consumers are not aware of the adverse impact of these new emerging micro-pollutants. There are over 100 factories in different areas of Dhaka, including Lalbagh, Hazaribagh and Sadarghat, and Chattogram that produce polythene bags. In Bangladesh, Environment and Social Development Organization (ESDO) is a pioneering organization of anti-plastic campaign and plastic ban, has taken the groundbreaking initiative to conduct a primary study on the extent of micro-plastics pollution in the three noteworthy urban communities (i.e. Dhaka, Chittagong and Sylhet) of Bangladesh in 2015 (ESDO 2016). The study which is the first-ever study in Bangladesh regarding micro-plastics pollution has reported that sixty most prevalent and commonly used beauty and cleaning products in Bangladesh, including face wash, detergent, body wash, nail polish, toothpaste, face, and body scrub contain micro-beads or micro-plastics. The study reported that every month around 7928.02 billion micro-beads are released into the encompassing water bodies and wastelands in and around the three noteworthy urban communities of Dhaka (about 6628.46 billion), Chittagong (about 1087.18 billion) and Sylhet (about 212.38 billion) (Fig. 08) (ESDO, 2016).

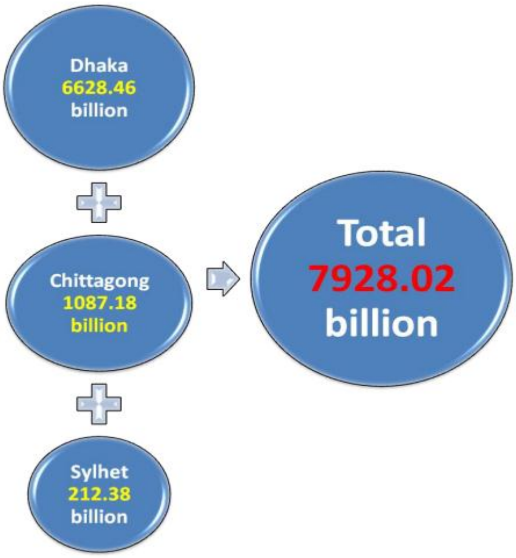

Fig. 08: Total amount of micro-beads release from three major cities in Bangladesh per month (ESDO, 2016 BD).

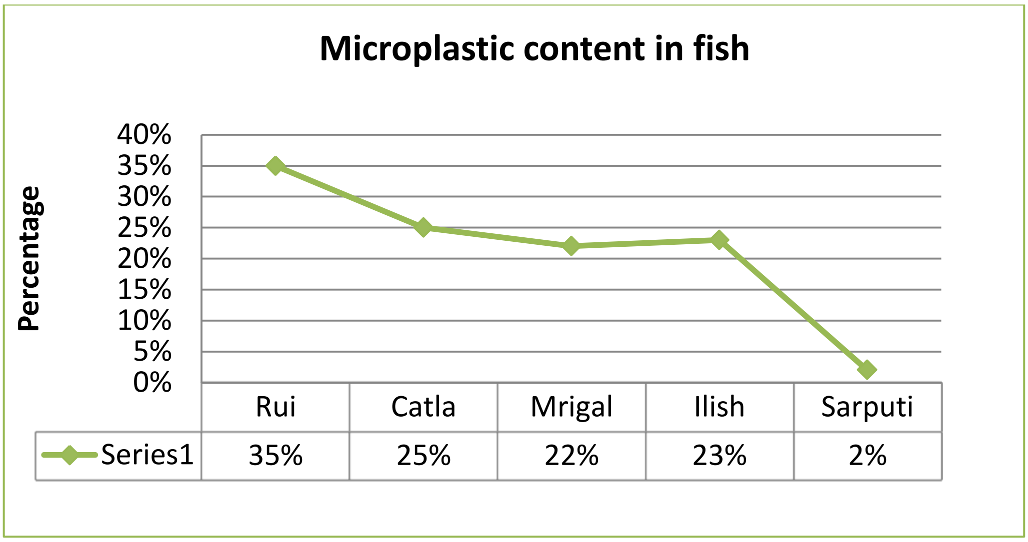

Fig. 09: Micro-plastic content in fish (ESDO, 2016 BD).

In the case of water pollution, about 100 fish samples of 5 species viz. Rui (*Labeo rohita*), Catla (*Gibelion catla*), Mrigal (*Cirrhinus mrigala*), Ilish (*Tenualosa ilisha*) and Sarpunti (*Puntius sarana*) were collected from different water bodies of Dhaka, Chittagong and Sylhet city. The study reported that larger fishes such as rui were more contaminated with micro-plastics than the smaller fishes such as Sarpunti (Fig. 09). Fishes of Dhaka city were found to contain a high amount of micro-plastic fragments (61%) whereas the least amount was observed in the fishes of the Sylhet city (8%). It was observed in a study conducted in Dhaka city that almost 40% fishes collected from the lakes of Dhaka city and Buriganga River contain micro-beads in their gut and respiratory. The contamination level of the fishes of lakes and ponds inside Dhaka city were more rather than the surrounding river fishes of the city (ESDO, 2016 BD).

Overall, it can be pointed out that micro-plastics are continuously contaminating wetlands, lakes, ponds, and rivers which eventually wash away to the Bay of Bengal and thereby affecting the marine lives and biodiversity there. From poisoning and injuring marine life to the ubiquitous distribution of these tiny plastic particles in human and animal food web, micro-plastics pollution is going to be a great threat for us, if it is uncontrolled.

Chapter 4

Conclusion

The occurrence and accumulation of MPs in the aquatic environment is nowadays an undeniable fact. It is also undeniable that a large number of organisms are exposed to these particles and this exposure may cause a variety of effects to threaten individuals of many different species, the ecosystems they live in and, ultimately, humans. Although the deleterious effect of MPs are well known but the global plastic production are alarmingly rising. If the plastic production remains continuous then in near future the aquatic ecosystem will face irreversible destruction and many of the vulnerable aquatic organisms will be extinct. So for making the better world for our generation it is crying need to avoid the use of plastic right now. It is impossible to stop the use of plastic if the general people are not concern about it. Government should take necessary steps to strictly maintain the laws of using plastic. The potential deleterious effects of MPs on aquatic biota have been recognized by the scientific community as demonstrated by the increasing number of studies in the last years focusing primarily on marine biota. However, the effects of MPs on freshwater organisms are much less well known.

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