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Microplastic Pollution In The Aquatic Environment, Applying A Case Study: Lower Danube-Black Sea Area - A Review

Daniela Laura Buruiana[1], Viorica Ghisman[1] and Cristian Dragos Obreja[1,]*

[1] Interdisciplinary Research Centre in the Field of Eco-Nano Technology and Advance materials CC-ITI, Faculty of Engineering, "Dunarea de Jos" University of Galati, Romania

Abstract**:** *Plastic pollution has become a global problem that is widespread across all compartments of the marine environment and there are insufficient data on the extent of plastic pollution in the Black Sea. Today`s rapidly developing and changing technologies within Covid 19 pandemic situation increased water pollution with plastic. Macroplastics are known to cause detrimental effects for wildlife. Individual animals can ingest large pieces or become entangled in plastic items, such as fishing gear, and suffocate or starve to death. Over time, macroplastics break up into small particles called microplastics (<5 mm in diameter), which can persist in the environment for hundreds of years. The importance of Microplastic Pollution in the Lower Danube-Black Sea Area in dealing with teaching the next generation to prevent a new environmental disaster regarding water pollution.*
The current review reveals the aquatic pollution with microplastics and its effects on flora, fauna and humans in the Danube- Black Sea Area.

Keywords: *microplastic, pollution. aquatic environment*

1. Introduction

The Danube River Area is covering 10% of Europe's surface in 19 states and is the second largest river area in Europe. It is possible to divide the upper, middle and lower Danube River Areas into three subregions. In the Upper Area, the Danube begins near its source in Germany and flows through Slovakia to Bratislava. Middle Basin, which stretches from Bratislava to the Iron Gate Gorge dams, is the largest subregion. Several lowlands, plateaux, and mountains make up the Danube River Lower Basin in Romania and Bulgaria [1-2].

Before it reaches the Black Sea the Danube River pass through Danube Delta. The Delta is comprised of three major branches before it reaches the sea. A large number of different species are able to survive in areas of high biodiversity because of the large area of the Danube River and its diverse habitats.

Over 2,000 vascular plants, mammals, and fish species call the Danube home. There are a number of protected natural areas located in the Danube meadow limits, where they aim to conserve and protect bird species, forests with original aspects, and samples with distinct landscapes, and in 1991, UNESCO designated it as a World Heritage Site in Romania and Ukraine. Besides being Europe's largest reed bed and wetland, the Danube Delta also functions as its largest water purification system [2].

Danube Delta is a natural museum comprising diverse habitats and wildlife within a limited geographical area, which makes it a natural gene bank for natural universal heritage. Over 70% of the vegetation is represented by reeds and rushes [1-3].

Among the different habitats found in the Danube Delta, as well as the proximity to several subzones of the palearctic faunal area, 4286 species of fauna are found there, including macroinvertebrate, fish, amphibians, reptiles, birds and mammals [2].

There are about 135 species of fish (representing about 75-80% of the Romania's ichthyofauna). There are mainly freshwater species, but there are also marine species in the Black Sea that enter the Danube during breeding season. Sturgeons and Danube mackerel are among the species taken for commercial purposes, with about a third being exploited through intensive commercial fishing [2].

Furthermore, the greatest number of ornithological species is found in the Danube Delta, with 365 species recorded to date. In winter, most of the European population of common pelicans and curly pelicans and over 50% of the world's population of small cormorants and red-necked geese [1-3].

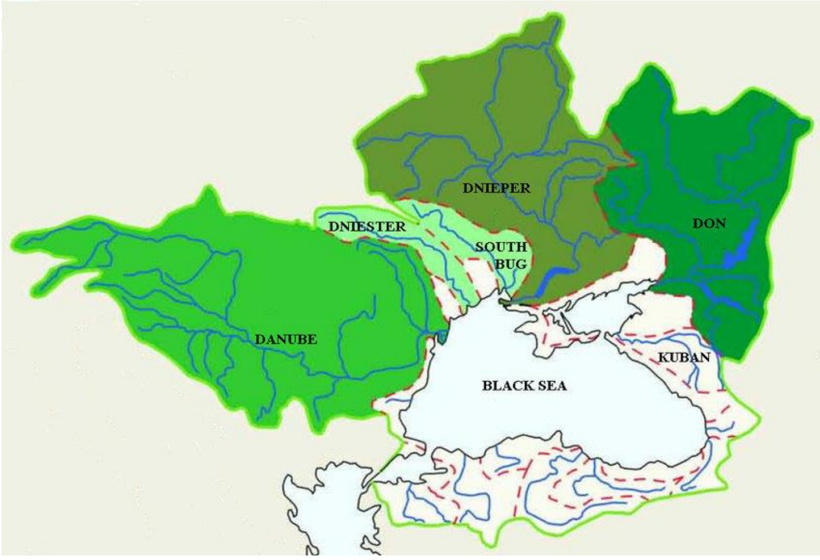

Fig. 1: Representation of the Danube-Black Sea Area [3].

Plastic particles with a size of maximum 5 mm are considered microplastics [4]. The sources of microplastics include microbeads from personal care products, fiber from synthetic clothing, pre-production pellets, and fragments from larger plastic products. Marine organisms can consume these smaller plastic particles. In mid-twentieth century, the chemical engineers were busy devising cheap ways to splice hydrocarbon molecules from petroleum into strands, in order to produce anything from coffee cups to toys and car parts. Compared to world GDP, plastic production has risen nearly three times faster from 2 million tons a year to 380 million tons in the past decade [4-7].

According to estimates, 6.3 billion tonnes of plastic waste have been produced since the 1950s, and only 9% have been recycled, while another 12% have been incinerated. However, the remainder was disposed in landfills or in the natural environment. In total, 8 to 13 million metric tons of plastic make their way into the oceans every year [2].

The Danube and the Black Sea are mainly littered with plastic waste. Microplastics are particles less than five millimeters in length (about the size of a sesame seed). Microplastics are a young field of study, so not much is known about their impacts. Tests are being conducted to standardize field methods for collecting sediment samples, sand samples, and surface-water microplastics samples. A global comparison of microplastics released into the environment will eventually be possible using field and laboratory protocols, which is the first step in determining their final distribution, impacts, and fate [2]. Many different types of microplastics are made, including by degrading larger plastic debris. Also known as microbeads, these are small pieces of manufactured polyethylene plastic that are added to a variety of health-and-beauty products, including toothpastes and cleansers [8-10].

2. Current situation and the plastisphere

A substantial percentage (47%) of debris in the Black Sea is plastic, likely introduced by river currents from neighbouring countries and the Danube basin. The information on land-based litter sources is still limited, and freshwater plastic pollution is subject to few continuous studies. In terms of current plastic pollution, the Danube-Black Sea basin is considered a fragile ecosystem. Several trash islands can be found in the Black Sea. A scientific study found that garbage collected from the Danube River most likely formed the island. Pollution in the Black Sea is mostly caused by the Danube River. Europe's most polluted sea, the Black Sea borders both Europe and Asia.

Plastic comes from a variety of sources, but the most common are either urban areas, rivers, sewage or tourism along the coast. An estimated 1500 tonnes per year are deposited into the Black Sea every day via the Danube. On the other hand, the Rhine carries between 20 and 30 tonnes of plastic litter per year to the North Sea and the Po river carries about 120 tonnes in the Mediterranean. [2] Researchers reported the composition and abundance of microplastics in sediments for the first time. Furthermore, a study sampled sediments from the region along the Lower Danube River immediately above the Iron Gates I dam, and from riverine and deltaic sites downstream, as well as from submarine sediments taken from depths of up to 120 meters along the Romanian and Bulgarian Black Sea shelf [4,6].

In the study, microplastics were hypothesized to be transported primarily along the Danube River.

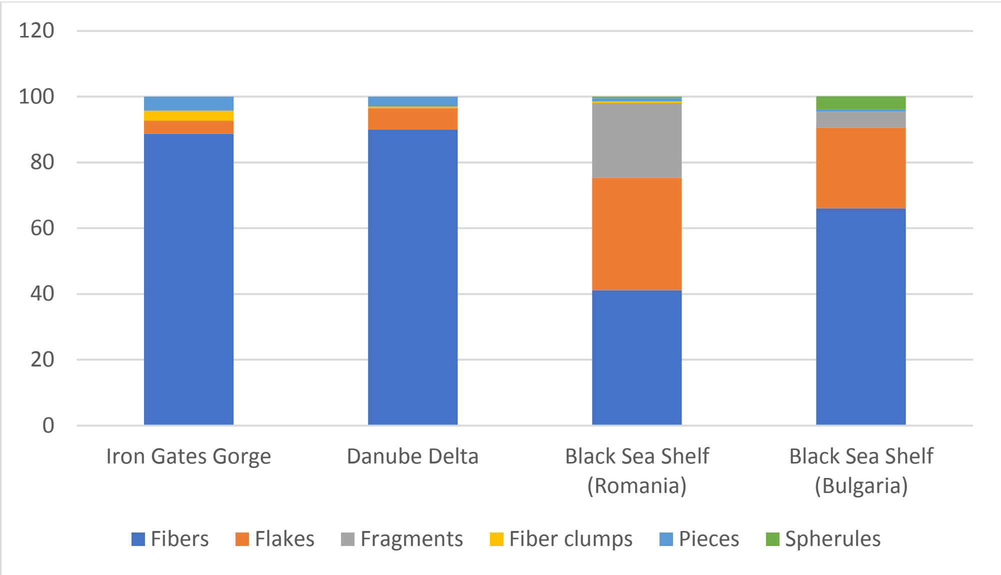

Fig. 2: Microplastics morphology in four sampling areas [4].

All sample locations had varying concentrations of microplastics. A moderate concentration of microplastic was observed along the Sulina-Sf. Gheorghe bifurcation in the Danube Delta. Deltaic lake sediments North of the Sulina branch had higher levels of microplastic than those in the Sulina and Sf Gheorghe branches. Bulgarian Black Sea microplastic concentrations were lower than those along the Danube Delta coast. Furthermore, only isolated areas of the Danube Delta are still free of microplastics [4,6].

There have been reports of floating garbage islands in the Black Sea by the Russian Academy of Sciences. An aerial survey of Black Sea dolphins and ecosystems in Russia at the end of September 2019 show a growing number of garbage islands in the Black Sea [2,7]. As a result of this survey, 450 small and large trash islands were registered. In addition to separate plastic structures, fragments of nets, and buoys, packages, bags, and sacks floated on the surface [7].

Researchers from the CeNoBS project reported that the marine areas of Ukraine, Bulgaria, Turkey, and Georgia accumulated more marine litter than those in Romania [2]. As noted by the experts, almost all of the litter that formed the "islands" and "streams" originated from the large rivers flowing into the Black Sea, especially the Danube. A square kilometre of the Black Sea has 90.5 litter items. The Mediterranean Sea has 50 litter items per square kilometre [4,5]. The Danube - Black Sea basin has not yet been assessed for its effects on plastic pollution and as a consequence updating surveys and studies must be initiated immediately [11].

In the past decades, researchers defined a new term, plastisphere. Scientists described the "plastisphere" as a vast new flotilla of microbial communities living on flecks of plastic that have polluted the oceans [2].

Plastispheres are novel ecological habitats in the ocean and sea. Scientists in the North Atlantic Ocean have collected plastic pieces with fine-scale nets and analysed them [12-13].

At least 1000 bacterial species have been identified on the plastic samples using scanning electron microscopy and gene sequencing. There were plants, algae, and bacteria that produced their own food, animals and bacteria that ate these, predators that consumed these, and other organisms that formed symbiotic relationships with them. [14] In the last 60 years, the oceans have been overwhelmed by plastic particles hardly bigger than a pinhead, creating these complex communities [2].

The bacteria living in the plastisphere were different from the species in surrounding seawater, which shows that plastic debris serves as an artificial "microbial reef". Plastics offer different conditions than those found in floating materials such as feathers, wood and algae, and can last much longer without degrading [14].

Different studies have determined that plastic debris may represent a new transportation method for microbes, including bacteria that cause disease and harmful algae. Scientists found that one sample of plastic was dominated by bacteria from the genus Vibrio, which causes cholera and gastrointestinal illnesses [2].

A recent study published in 2021, asserts an important distinction between the plastisphere and the aquatic environment. Freshwater and seawater ecosystems displayed these functional differences differently [15]. Plastispheres vary in response to salinity, nitrogen related ions, and dissolved organic carbon concentration in their environments. In the plastisphere, physicochemical properties explain fewer variations in microbial communities than in aquatic environments. The plastisphere community is assembled by niche-based processes, while the aquatic environment is assembled by neutral processes. The plastisphere is less complex, is more modular, has a higher modularity, and is also more competitive than an aquatic ecosystem but the opposite is true for seawater ecosystems. Plastisphere, a new anthropogenic ecosystem, exerts different effects on freshwater and marine ecosystems due to its unique microbial ecology [14-16].

3. Microplastics effects over the ecosystem

Marine mammals and birds commonly ingest or become entangled in plastic debris, which can cause them to suffocate, starve, and drown [16]. Each year, thousands of marine animals become entangled in plastic waste; this limits their ability to move and feed, as well as injuring them and causing infections. Furthermore, seabirds, turtles, and fish frequently mistake plastic waste for food, since some plastic waste shares similar colour and shape as their prey, as well as because floating plastic accumulates microbes and algae on its surface that give it an odour that is appealing to some sea creatures [17-18].

Plastic can cause internal organ damage or intestinal blockages in animals who consume it; it can also cause starvation because an overstuffed stomach gives an animal the illusion of being full [19-20]. In fact, plastic are similar to plankton, which is food for many species at the bottom of the food chain, which means that plastic permeates entire ecosystems [19-22]. Additionally, plastic absorbs pollutants that float in the ocean, and contains harmful chemicals. As a result of consuming these particles, animals may experience organ damage, become more vulnerable to disease, and have altered reproduction [2].

Approximately 60% of sea birds have plastic in their gut, calculating that 9 out of 10 seabirds have eaten some form of plastic, and estimating that by 2050 most seabird species will have consumed plastic. Plastic particles can bioaccumulate after being consumed, concentrating toxicity and plastic particles in predators. Humans are among these predators [20]. Fish destined for human consumption have been found to contain plastic. In one study, plastic pellets were found in the stomachs of 22% of the fish examined. According to another study, European consumers of shellfish can be exposed to up to 11.000 pieces of microplastic per year through their diet. In fact, plastic is so ubiquitous that even tap water contains it. There were plastic fibers in 83 percent of all tap water samples tested, according to a study. Furthermore, there are tiny plastic fibers in beer, honey, and sugar, and they can be found in the air of urban areas [2,17].

In a recent study, microplastic was found in snow and streams on Mount Everest indicating that microplastic is ubiquitous. Moreover, the pollution of coastal communities, fisheries, and economies is not limited to destroying ecosystems and killing marine animals [2]. Marine plastic pollution negatively impacts marine ecosystems and wildlife, as well as tourism, cultural heritage and fisheries that depend on these animals and ecosystems.

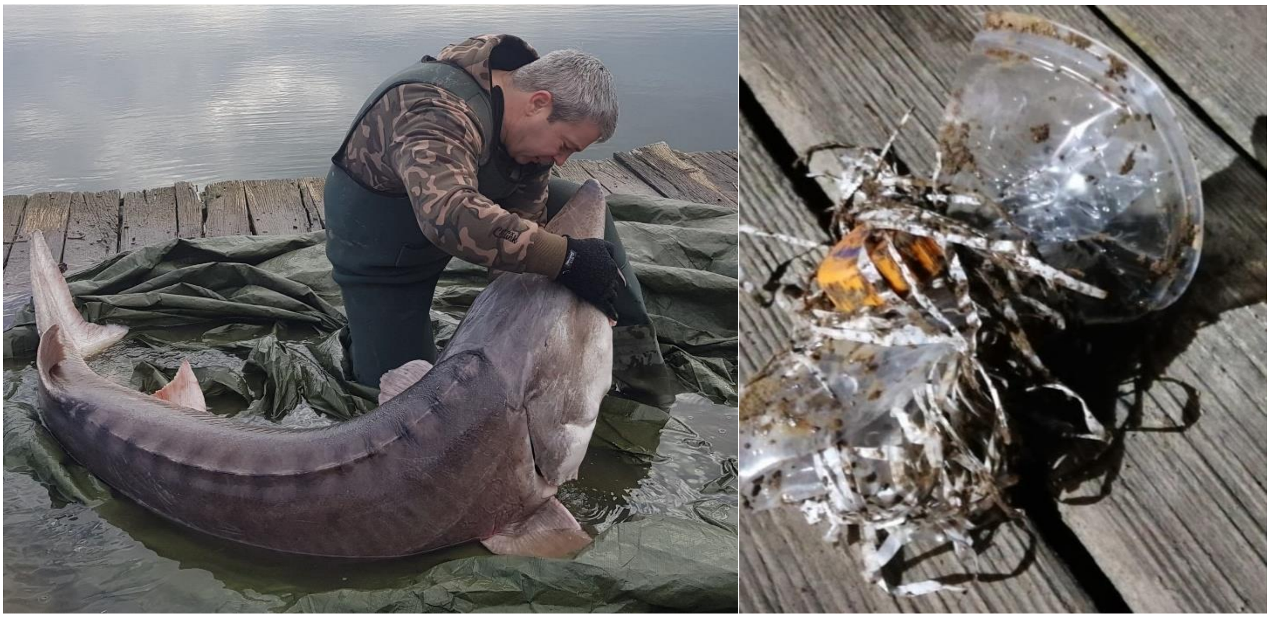

Fig. 3: Sturgeon saved from the after he ingested plastic [26].

The degradation of plastic results in the release of toxic chemicals into the environment and in humans [24-25]. As a result of fragmenting and microplastics entering the body directly, they can affect a wide range of health issues, including cardiovascular disease, cancer, and autoimmune conditions.

4. Conclusions

Because of their buoyancy, durability, lightness and shape, microplastics have been observed, by current studies to move great distances around the globe. As contaminants of concern, microplastics should be regarded as a global change factor given their ubiquity. Ingestion of microplastics is not only harmful to organisms because of the material itself, but also because of the material's ability to absorb and concentrate marine pollutants in the surrounding environment and subsequently transfer them through food chains.

Existing studies show that most of the plastic was found near the mouth of the Danube River, likely originating in the Lower Danube basin. Furthermore, the concentrations in the Black Sea, south of the Delta, were significantly lower. Therefore, it can be assumed that a high amount of plastic is transported into the Black Sea via the Danube River.

An investigation of plastic pollution and waste management in the Danube Black Sea Basin should be directed towards developing contingency plans for future plastic pollution and waste management.

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