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Plastic waste in Vietnam and potential impacts of plastic and microplastic pollution

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ABSTRACT
The paper has applied some research methods to preliminarily assess plastic waste in Vietnam and some negative impacts of plastic and microplastic pollution on human health, biological as well as socio-economic. Research results showed that plastic waste in Vietnam arises from many different sources; The total amount of plastic waste in Vietnam is 3.27 million tons/year, accounting for about 8-12% of household solid waste and about 5% of medical waste; The treatment and recycling of plastic waste is still limited, up to 90% of plastic waste is burned, buried or discharged into the environment, only about 10% of plastic waste is recycled. Microplastics from many sources penetrate the soil, water, and air environments, changing the composition and properties of natural environmental components, and are agents that absorb many environmental toxins, negatively affecting the normal development of humans and living organisms. Many studies have identified microplastics in oysters, mussels, scallops, bottled mineral water, beer, tap water, table salt, canned foods, honey and sugar... Although the concentration is low, if exposed and long-term absorption of microplastics will pose a potential threat to human health (such as causing hormonal imbalance, neurological diseases, respiratory diseases, affecting brain structure), causing hyperactivity, weakening and changing the immune system... For living creatures, microplastics can cause effects such as reducing movement, causing gastrointestinal blockage, and impaired development, restricting reproduction, changing behavior and sense of smell. For socio-economic activities, microplastics reduce commercial value, causing damage to the seafood industry, while consumers lose a valuable, safe and nutritious food source…

KEYWORDS: *plastic, waste, pollution, environmental management, Vietnam*

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I. INTRODUCTION

Plastic pollution is one of the biggest challenges facing countries around the world. Each year, the amount of plastic waste generated by humans globally is enough to cover four times the Earth's surface area, of which 13 million tons of plastic waste is dumped into the ocean. The abuse of plastic products, especially non-degradable plastic bags and single-use plastic products, has left serious consequences for the environment. Most plastic waste has a very slow biodegradation rate, will break into smaller particles and then become microplastics - plastic particles with a diameter of 1µm - 5mm. The amount of plastic waste discharged into the environment is increasing, causing harm to the environment and ecosystems. Microplastic particles accumulate in organisms along the food chain, causing adverse effects on human health.

Currently, microplastics are found everywhere in the world from rivers, ponds, lakes, canals, streams, to coastal sandbanks, present in groundwater, seawater, oceans, and layers. sediment on the sea bottom. Microplastics are also found in the air, in mangrove forests, both in the Arctic and Antarctica and in streams on Mount Everest and remote Tibet...

Recent studies show that the total amount of virgin plastic produced from the year plastic was mass produced (1950) to 2015 was 8,300 million tons. As of 2015, about 6,300 million tons of plastic waste were generated, about 9% of which was recycled, 12% was burned and 79% was sent to landfills, accumulating in the natural environment.

It is estimated that each year the amount of plastic waste generated is about 12 million tons, of which 2 million tons accumulates inland; 8 million tons of plastic fragments (> 5 mm) and 1.5 million tons of primary microplastics poured into the ocean; and 0.6 million tons of fishing nets were thrown into the sea [1].

Microplastic pollution in oceans and seas varies by geographical region globally, highest in India and South Asia (18.3%), North America (17.2%), followed by Europe and Central Asia (15.9%), China (15.8%), East Asia and Oceania (15.0%), South America (9.1%), Africa and the Middle East (8 ,7%) [2].

It is estimated that by 2050, if the amount of plastic waste increases at the rate of increase in annual plastic production worldwide in the period 2005-2015 and there are no active measures to reduce plastic waste, the number of plastic fragments on ocean and coastal surfaces could double compared to 2020 (about 4.5 million tons). At that time, nearly 3 million tons of plastic pieces will be decomposed into microplastics. If the amount of plastic waste entering the ocean is kept constant from 2020 onwards, the volume of plastic debris on ocean and coastal surfaces continues to increase albeit at a slower rate due to the breakdown of old plastic debris into smaller plastic particles [3], [4].

Currently, although there is still no specific international maritime law on microplastics, many responses have been implemented through voluntary or legally binding measures at the international, regional and national levels.

Many countries around the world have begun to pay attention and promulgate measures and policies to prevent and control environmental pollution caused by plastic and microplastics. In 2015, the United States issued a ban on cosmetics that use microplastics. The UK also introduced a ban on the use of microplastics in toothpaste and detergents in 2017 [5]. In Taiwan, from 2018, it is prohibited to produce or distribute cosmetics and personal care products containing microplastics. Italy bans the sale of cosmetic products containing microplastics from January 1, 2020. On January 18, 2019, the European Union Chemicals Agency (ECHA) also proposed to ban manufacturers from adding microplastics to products such as cosmetics, detergents and agricultural fertilizers from 2020. Currently, the United Nations Environment Program (UNEP) is continuing its efforts to call on countries to ban the use of microplastics in personal care products and cosmetics [6].

Vietnam is a country with a long coastline and is one of the countries with the highest amount of plastic waste in the ocean in the world. In 2010, Vietnam was the country with the fourth highest amount of plastic waste dumped into the ocean in the world, after China, the Philippines and Indonesia. Recognizing the environmental risks of plastic waste, the State has issued many documents regulating plastic waste management as well as action plans to reduce plastic and microplastic pollution. However, plastic waste management in Vietnam still has many shortcomings, so the study *"Plastic waste in Vietnam and potential impacts of plastic and microplastic pollution"* was conducted to provide more database on plastic waste pollution in Vietnam, some negative impacts of plastic and microplastic pollution on human health, organisms as well as socio-economics. Research results are auseful premise to help scientists and authorities at all levels propose effective solutions to reduce plastic waste and to limit their potential impacts in the future

II. RESEARCH SUBJECTS AND METHODS

Research subjects: The paper focuses on researching the issue of plastic and microplastic pollution in Vietnam and some potential impacts of plastic and microplastic pollution in general.

Research Methods:

- Method of collecting documents and primary data: Collect documents related to the research content of the article, such as the Law on Environmental Protection, legal documents, and Decisions of the Prime Minister, research projects on plastic waste and legal policies related to plastic and microplastic pollution management in Vietnam and some countries around the world as well as some potential impacts of plastic and microplastic pollution in general.
- Data analysis and synthesis method: Synthesize research documents on plastic waste and legal policies related to plastic waste,plastic and microplastic pollution management in Vietnam and some other countries as well as some potential impacts of plastic and microplastic pollution in general.

III. RESULTS AND DISCUSSION

3.1. Plastic waste and microplastic pollution in Vietnam:

The types of plastic waste generated in Vietnam are mainly plastic bags, dirty plastic bottles, single-use plastic products, plastic products that are difficult to recover, difficult to recycle, ... arising from daily activities, consumption, and socio-economic activities including:

- Packaging: 40% of plastic produced is used for packaging, food packaging, household appliances, and industrial products;
- Agriculture: plastic waste can arise from the farming process such as plastic covering soil and wrapping fruit, fertilizer packaging, pesticide packaging - exists in the form of plastic bottles and zinc-coated plastic bags, which are difficult to decomposes and is classified as hazardous waste;
- Construction: plastic is used a lot to make door frames, plastic doors, gates, scaffolding, tables and chairs, cabinets, and plastic fabric covering construction projects;
- Tourism: plastic waste from tourist activities, boats, and tourism businesses;
- Plastic recycling: plastic loss from the recycling process, eliminating non-recyclable plastic products mixed in recycled plastic.

Land-based industries that generate microplastics in Vietnam include:

+ Cosmetics and personal care products manufacturing industry: In addition to the plastic ingredients used to contain and package products, each time a person uses an exfoliating product, there will be about 4,600-94,500 microplastics are released;
+ The textile industry also releases large amounts of microplastics during the washing process; + Transport industry: microplastic dust is mainly smaller than 80 µm in size and is generated from worn tires;
+ Plastic production and manufacturing: plastic flow is lost due to the plastic transportation process;
+ Ship maintenance and demolition: cleaning ship hulls and storage compartments creates a lot of microplastics;
+ Wastewater treatment: conventional wastewater treatment facilities cannot retain or process microplastics. Meanwhile, the source of microplastics at sea is due to the accidental loss of goods, the use of personal care products and cosmetics by passengers on cruise ships.

Vietnam is facing many potential risks from plastic waste. The amount of plastic waste is increasing rapidly. According to statistics from the Ministry of Natural Resources and Environment, in 2014 Vietnam had about 1.8 million tons of plastic waste discharged into the environment, in 2016 there was about 2.0 million tons of plastic waste generated and currently there are about 3.27 million tons of plastic waste are generated each year in Vietnam. The volume of plastic waste dumped into the ocean each year is about 0.28 - 0.73 million tons (accounting for nearly 6% of the world's total amount of plastic waste discharged into the ocean). In two large cities, Hanoi and Ho Chi Minh City, an average of about 80 tons of plastic waste and nylon bags are discharged into the environment every day [7].

The classification, recovery, recycling and treatment of plastic waste is still limited. The amount of plastic waste and nylon bags in Vietnam accounts for about 8-12% of household solid waste. But only about 11-12% of plastic waste and nylon bags are processed and recycled, the rest is mainly buried, burned and discharged into the environment. This is one of the basic causes of plastic pollution in Vietnam. Besides, about 5% of medical waste is plastic waste. Every day, about 22 tons of plastic waste is discharged from medical activities, some of which is mixed with hazardous waste (medicines, chemicals, etc.). Collecting, recycling and burying this type of plastic waste all affect public health and environmental pollution.

Up to now, Vietnam has not had official statistics on the current status of microplastic pollution nor has there been an overall assessment of its sources (from cleaning products, cosmetics, laundry activities, and textiles, traffic...) and the current situation of microplastics in the environment (soil, water, air) in Vietnam.

However, recently there have been a number of studies determining the distribution and content of microplastics in some sediment and water environment samples. Research on the level of microplastic pollution in water and sediment of the Saigon – Dongnai river, which provides up to 94% of raw water to produce drinking and domestic water for the people of Ho Chi Minh City, with 18 researchers. Sampling and analysis of microplastics in surface water and sediment environments (including 13 locations on the Saigon River and 5 locations on the Dong Nai River) shows that the water is not only polluted with organic and physicochemical parameters but also polluted due to microplastic emissions. The results showed the appearance of microplastics in the form of pieces, fibers and microplastics from 0.1–5 mm in size. In water, fibrous microplastics have from 228,120 to 715,124 fibers/m3 of water, while fragmented microplastics have 11 to 222 pieces/m3 of water. In sediment, microplastics ranged from 6.47 ± 1.45 to 52.32 ± 4.92 mg/kg, with an average of 21.77 ± 6.9 mg/kg. In which PE (51.2%), PP (27.1%), PVC (13.4%) and other plastics (8.3%) [8].

Microplastics were also found in all three sea areas of Tien Giang, Can Gio and Ba Ria - Vung Tau with densities ranging from 0.04 to 0.82 pieces/m3 of seawater, lowest in Can Gio and highest in Tien Giang. The common characteristics of microplastics in these three sea areas are flakes and fibers, concentrated sizes between 0.25-0.5mm and 1-2.8mm, with quite diverse colors [9], [10].

In tidal flat sediments in Hau Loc district, Thanh Hoa province, the content of microplastics in the sediment ranges from 0.002 - 0.0798 g/kg with an average value of 0.0229±0.0089 g/kg, corresponding to 2532-6875 pieces of plastic /kg sediment [11].

In the Ba Lat Estuary (Red River estuary), Northern Vietnam, the distribution of microplastics varies widely, with densities ranging from 70 to 2,830 microplastics per kilogram of dry surface sediment. Microplastics measuring 300 - 5,000 µm account for more than 88% of the total number of particles. Fibers are the dominant shape in all samples, followed by membranes and granules. The detected microplastics were mainly transparent, red and blue. Polyethylene (PE), polyamide (PA) and polypropylene (PP) are the three main types of plastic found in surface sediments in the Ba Lat estuary [12].

3.2. Impacts of microplastic pollution

Microplastics are a type of waste that pollutes the living environment, especially the oceans, is harmful to aquatic animals and causes many harmful effects to human health. These small plastic particles pass through the wastewater treatment system into rivers, lakes, ponds and oceans, from where they greatly affect the environment as well as the food chain.When microplastics mix with water sources, they will absorb toxins in the water and become very toxic; Because of their insoluble and difficult to decompose properties, thousands of

microplastic particles accumulate in the bodies of plants and animals along the food chain. The use of marine creatures and marine products, even sea salt containing microplastics, as food seriously affects human health. According to research results conducted by scientists in Korea and Greenpeace Asia, up to 90% of salt products sampled from many parts of the world are contaminated with microplastics [13]. In addition, 83% of water samples tested around the world contain microplastic particles. Every broken microplastic particle will produce many toxins that can be dangerous to human health such as causing hormonal imbalance, neurological diseases, respiratory diseases, affecting the brain structure, causing hyperactivity, weakness and immune system changes and a series of other risks [14].

3.2.1.Impacts on living creatures

The type of plastic particles an organism ingests depends on the characteristics and behavior of the organism as well as the range of plastic particles the organism is exposed to. Microplastics are common in the guts of dead seabirds such as northern albatrosses (Fulmarus glacialis) and there is evidence that plastics can be transferred from prey to predators such as great robins (Stercorarius skua) [15].

Microplastics are also found in many commercial species such as mussels, clams, oysters, and scallops. Many bivalves and mollusks feed by filtering water, live in shallow waters near shore, and are more likely to be exposed to higher concentrations of microplastics than non-attached and motile species.

Microplastics in shellfish range in size from 5 µm - 5 mm and can be debris, particles or fibers. For example, in 8 of 9 shellfish species sampled in markets in Asia, fibers accounted for more than 52% of the internal contents in one species, with the exception of A. plicata where plastic beads accounted for the largest proportion. (60%). A European study of M. edulis also found that synthetic fibers were the most common type of microplastic, with sizes ranging from 200µm to 1,500µm. Microplastics have also been found in many commercial shellfish species, most in less than one piece but some species with up to 75 pieces per individual depending on the location.

The specific impact of microplastics is receiving more attention and is still poorly understood because it is difficult to quantify microplastics in animal tissue. Research on mussels shows that microplastics move from the digestive tract into the circulatory system within 3 days and stay for more than 48 days. The study also found more small-sized microplastic particles (3.0 µm) in circulating fluid than large particles (9.6 µm), meaning that smaller particles have a greater risk of accumulating in an organism's tissues.

In aquatic systems, microplastics are also found in many different animals such as corals, polychaetes, zooplankton, rotifers, crustaceans, mollusks, fish, and sea cucumbers. Consuming microplastics can cause many effects such as polymer adhesion to organ surfaces, reducing movement and causing gastrointestinal blockage; or cause symptoms of inflammation, stress and impaired development (Auta et al., 2017). On the other hand, plastic can directly or indirectly affect the quality of physicochemical factors of the environment such as changing light intensity in water bodies and sediment characteristics (EerkesMedrano et al., 2015). Microplastics can adsorb onto green algae (Scenedesmus, Chlorella) reducing photosynthesis and increasing oxidants through reducing light intensity or hindering CO2 and nutrient metabolism (Anderson et al., 2016). Microplastics negatively affect the vitality, development, reproduction, size of offspring and cause deformities of the microcrustacean Daphnia magna (Anderson et al., 2016). The negative effects of microplastics on the development, filtration and egg laying of saltwater zooplankton have been documented (Anderson et al., 2016; Auta et al., 2017). Microplastics can cause septicemia of some specialized cells in sea urchins and reduce lipid reserves, increasing inflammation and oxidative stress in worms. Sea bass eat and accumulate microplastics, leading to impaired growth, limited reproduction and changes in behavior and sense of smell, thus increasing the risk of vulnerability to their enemies [16].

3.2.2. Impacts on human health

Microplastic particles in the water environment have been absorbed by the bodies of different organisms, from plankton, fish, birds... In turn, humans will eat fish and put microplastic particles into their bodies. According to a study in Belgium in 2014, if you regularly eat seafood such as clams and oysters at every meal, the number of microplastic particles entering your body can be about 11,000 particles a year. If you eat clams or oysters - each one contains at least 8 microplastic particles in the meat, even visible to the naked eye. Every year each person inhales 13,731- 68,415 microplastics from household items [17].

Although there is clear evidence that humans are exposed to microplastics through food and that the presence of microplastics in seafood can threaten food safety (Table 1), there is still a large gap in understanding the reactions and toxicity of microplastics in the human body. Microplastics can also carry pathogenic

microorganisms (bacteria, viruses) that are potentially harmful to aquaculture and exploitation activities and human health [15].On the other hand, plastic particles in water can be accompanied by metals such as Cd, Cu, Ni, Pb, Zn, Co (Anderson et al., 2016), increasing metal concentrations in exposure to animals that eat plastic particles. Plastic debris can increase the concentration of hazardous substances millions of times compared to the surrounding environment. Organic pollutants attached to microplastic surfaces can cause adverse effects on consumers and be transferred to predators higher in the food chain, including humans, however, understanding of this is very limited (Anderson et al., 2016).Therefore, microplastics can cause bad diseases such as cancer, reproductive damage, immunodeficiency and deformities in animals and humans (Auta et al., 2017).

Table 1. Microplastic concentration in some foods [15]

Species	***Quantity of microplastics per kg (wet weight) or 1 liter of product***
Green mussels (North Sea)	260-13,200
Brown shrimp (North Sea)	680
Honey (many brands)	0.09-0.29
Beer (Germany)	2-79 strands12-109 pieces 2-66 grains
Salt (China):	
Sea salt	550-681
Lake salt	43-364
Mine salt/well salt	7-204

Microplastic particles always exist on the surface of plastic bags, plastic cups, plastic spoons, and disposable plastic food containers. Therefore, when using food in plastic bags, plastic cups, plastic spoons, and disposable food containers, people are also putting an amount of microplastic particles into their bodies. Meanwhile, microplastics also take 400 to more than 1,000 years to decompose. When entering the human body, they can cause harmful effects on health. Scientists have clear evidence of the carcinogenic and infertility effects of plastic additives (plasticizers, substances that increase hardness, durability or fire resistance) on the human body and living creatures, accompanied by reproductive dysfunction, hormone disorders, genetic mutations in young children, cancer in people with frequent contact and other incurable diseases [18].

3.2.3. Impacts on economy and society

For fisheries, plastic can pollute or cause disease in fish species, reduce commercial value and consume more time to clean and repair nets and boats. If consumers perceive that seafood containing microplastics has the potential to pose risks, it will lead to behavioral changes (e.g., reduced seafood consumption). Obviously, this causes loss of income for the seafood industry, while consumers lose a safe and nutritious source of protein [15].

IV. CONCLUSION

Plastic and microplastic waste in Vietnam are generated from many different sources. Every year Vietnam has about 3.27 million tons of plastic waste discharged into the environment. The amount of plastic waste and nylon bags in Vietnam accounts for about 8-12% of household solid waste and about 5% of medical waste. The treatment and recycling of plastic waste is still limited, up to 90% of plastic waste is burned, buried and discharged into the environment, only about 10% of plastic waste is recycled.Vietnam has not had official statistics on the current status of microplastic pollution nor has there been an overall assessment of its sources (from cleaning products, cosmetics, laundry activities, and textiles, traffic...) and the current situation of microplastics in the environment (soil, water, air) in Vietnam. However, recently there have been a number of studies determining the distribution and content of microplastics in some sediment and water environment samples.

Microplastics from many different sources penetrate the soil, water, and air environments, changing the composition and properties of natural environmental components, and are agents that absorb many environmental toxins, negatively affecting the normal development of humans and living organisms. Many studies have identified microplastics in oysters, mussels, scallops, bottled mineral water, beer, tap water, table salt, canned foods, honey and sugar... Although the concentration is low, if exposed and long-term absorption of microplastics will pose a potential threat to human health (such as causing hormonal imbalance, neurological diseases, respiratory diseases, affecting brain structure), causing hyperactivity, weakening and changing the immune system... For living creatures, microplastics can cause many effects such as reducing movement, causing gastrointestinal blockage, and impaired development, restricting reproduction, changing behavior and sense of smell. For socio-economic activities, microplastics can pollute water sources, accumulate in the food chain, reduce commercial value, and cause damage to the seafood industry, and consumers lose a valuable, safe and nutritious food source.

Conflict of interest:

There is no conflict to disclose.

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