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## Initial survey on microplastic waste in coastal water in Nam Dinh

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### ABSTRACT

Plastic materials are defined as including the whole of organic polymers owning plasticity. Their production increases rapidly due to their superior properties and applications in our life. Currently, the annual production of plastic is estimated at nearly 400 million tons. About 10% of the plastic produced is discharged into the seas and oceans. Microplastics (MP, less than 5 mm in size) are non-biodegradable and persistent in the environment and have the ability to accumulate in various environmental components, organisms and other human beings through the food chain. Therefore, assessing microplastic pollution becomes essential for the marine and ocean environment. This study aims to evaluate microplastic pollution in Nam Dinh seawater. Water samples were taken in summer 2020 and spring 2021 in Giao Thuy district, Nam Dinh province. Samples were treated with 30% H<sub>2</sub>O<sub>2</sub> solution to remove organic matters and then microplastic buoyantly separated using saturated NaCl solution. MP was identified through observation under a stereo microscope (Olympus SZX2-TR300) and its nature was determined through infrared spectroscopy ( $\mu$ FTIR). Results show that a large level of pollution (average 6 to 8 particles/m<sup>3</sup> and 10–14 million particles/km<sup>2</sup>) is associated with the predominant of colored fibers among MP characteristics. Most of the microplastics identified are Polypropylene in nature. Next, more research needs to be invested in this pollution problem, such as expanding the scope and research object.

**Keywords:** Microplastic, marine pollution, seawater, infrared spectroscopy, Polypropylene.

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## **INTRODUCTION**

Humans have used natural polymers as materials such as rubber since the beginning of the 16<sup>th</sup> century. The introduction of synthetic organic polymers (plastics) only appeared in the early years of the 20<sup>th</sup> century. The demand for plastic materials increases rapidly because of outstanding properties such as lightness, ease of molding, bending, water resistance, chemical resistance, and durability. As the demand rises, plastic production has increased more than 200 times in just 70 years, from 1.5 million tons in the 1950s [1] to over 300 million tons in 2020 [2]. Recent estimates put the total number of plastics produced at more than 8 billion tons [3]. Only 9% are reused, and nearly 80% are discharged into the environment. Many types of plastic are used once, such as drinking cups, food containers, and packaging, before being directly released, which is very harmful to the natural environment [4]. Jambeck et al., (2015) estimated that about 11% (275 million tons) of plastic waste is generated by the population of 192 countries, most of which belong to China and Southeast Asian countries. We estimate that in 2010, 4.8 to 12.7 million tons of plastic waste were discharged into the oceans, and by 2025 this number will increase to 250 million tons [5]. In the natural environment, large pieces of plastic over time will break into small pieces as microplastics (from 1  $\mu\text{m}$  to 5 mm) under the influence of physico-chemical-biological agents [6], making the primary source of microplastics besides microplastic particles/fragments used directly in products such as toothpaste and cosmetics. With the small size, microplastics can spread widely in water and air, accumulating in sediments as well as in the body of organisms and humans [7]. Several recent studies have shown the harmful effects of microplastics on organisms as well as humans [8]. Environmental pollution in general and plastic waste pollution is a global hot issues. In Vietnam, in recent years, rapid urbanization, population growth, and strong development in agricultural and industrial production have been affecting water pollution and problems of plastic waste and microplastics. As one of the most countries discharging plastic waste into the ocean in the

world, research on plastic pollution in general and microplastic pollution in particular in Vietnam is still limited. Therefore, the objectives of this study are: (i) to assess the level of microplastic pollution in the coastal water in Nam Dinh, an abundance of activities such as tourism and aquaculture location, (ii) to analyze the characteristics of pollution, trace pollution sources and (iii) compare pollution levels with other studies in the world as well as propose research directions in the future.

## **MATERIALS AND METHODS**

### **Sampling**

Seawater was sampled in Giao Thuy district, Nam Dinh province (July 2020 and January 2021, Figure 1). Samples were taken at 2 locations at high tide according to standard methods (manta net with a diameter of 50 cm, mesh size of 80  $\mu\text{m}$ , time of 60 seconds, speed of 5  $\text{km}\cdot\text{h}^{-1}$ ). At each location, seawater is collected from 3 points at least 50 m apart. Information such as pH, salinity, temperature, and wind speed was measured in detail at the sampling time (Table 1). The sample was recovered (water in the beaker) with pure water in a clean glass vessel, pooling 3 points into a glass flask (1 liter). Seal, label, and store cool during transport to the laboratory, where samples are stored at  $-20^{\circ}\text{C}$  until analysis. A total of 4 seawater samples were studied.

### **Sample processing**

MP analysis in seawater samples was applied according to current procedures [8]. After 2–4 hours of thawing, the water sample was left in the beaker. At each study site, 5 replicates were performed. Biological tissue residues will hinder the observation and identification of microplastics. Therefore, they were digested with 30%  $\text{H}_2\text{O}_2$  solution (purity  $> 99\%$ , Xilong Scientific, China). Hydrogen peroxide was added several times, little by little, and gently heated at  $40^{\circ}\text{C}$  until no visible biological tissue residue remained. Microplastic floatation step will be applied through the use of saturated NaCl solution (Shanghai Zhanyun Chemical, China) (density  $1.2 \text{ mL}^{-1}$ ). The microplastics in the sample are separated through a filtration step (0.7  $\mu\text{m}$  fiberglass membrane, Whatman). The filter membrane

will be dried under normal conditions and stored tightly closed until MP is analyzed.

**Sample analysis**

Dried membrane filter will be observed under a stereo microscope (Olympus SZX2-TR300, 300x magnification). Acceptance criteria for microplastics for observed objects are as suggested by Nor and Obbard [9]. For example, the observed object does not have organic structures; the color is uniform on the entire object’s surface. Observation is carried out by at least 2 experienced and independent experts. Observation results of each person will be aggregated with complete information such as position (value of two axes *OX* and *OY*), color, shape, and size (maximum, minimum). Microplastics are accepted as observed by both experts. The nature of microplastics and some particles/fibers were examined by measuring infrared spectroscopy

( $\mu$ FTIR\_Thermo\_Nicolet\_iZ10). Each measurement using the transmittance method was made with 8 accumulations over the wavelength range  $4,000\text{ cm}^{-1}$  to  $1,300\text{ cm}^{-1}$ . Reference spectral data and acceptance criteria for the measured spectrum were used through the siMPle software. All experiments were performed in a clean laboratory, in a bottle cabinet, tightly sealed with aluminum foil as much as possible to ensure analytical quality. The requirements for gloves and blouses are strictly guaranteed. The analysis blank using double distilled water of the same volume as the sample was carried out parallel to the seawater sample. Analytical results are corrected with blank samples, and the microplastic concentration unit is calculated according to the number of microplastics (mean, standard deviation) by area (microplastics per  $\text{km}^2$ ) and volume (microplastics in  $\text{m}^3$ ) of seawater sampled.

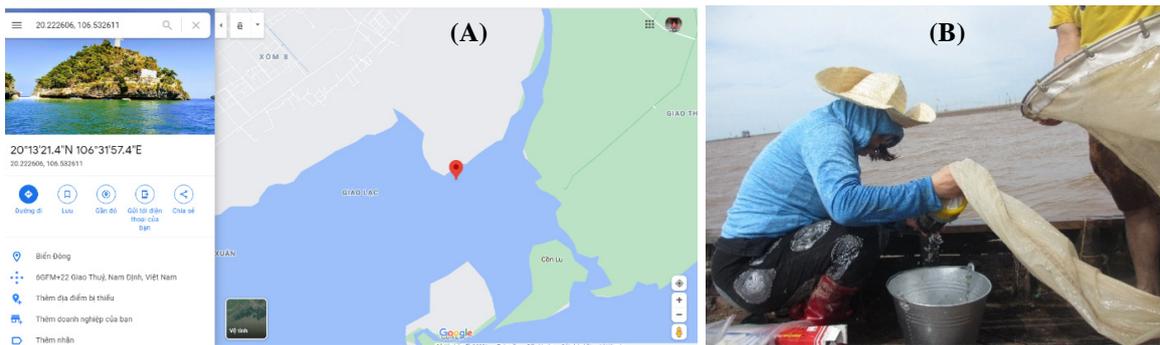


Figure 1. Sampling location of seawater (A) and sampling method (B) in Nam Dinh (illustration for S1 location in July 2020)

Table 1. Environmental parameters of Nam Dinh seawater in the study area at the time of sampling

Value	Parameters (average $\pm$ standard deviation, $N = 3$ )			
	pH	Temperature ( $^{\circ}\text{C}$ )	Salinity (%)	Wind ( $\text{km.h}^{-1}$ )
	$6.91 \pm 0.06$	$27.10 \pm 0.17$	$3.02 \pm 0.12$	$6.70 \pm 0.35$

**RESULTS AND DISCUSSIONS**

**MP concentration**

Figure 2 shows that the average concentration of microplastics in seawater in Nam Dinh was recorded in the range of 10.6–14.4 million microplastics/ $\text{km}^2$  (6.7–9.2 microplastics/ $\text{m}^3$ ). The two study sites

differed by distance from the coastline. The results show that there is not enough to difference significant between these two locations ( $p > 0.05$ ) even though the location S2 is taken at the exit area of the sluice gate. Meanwhile, seawater samples in spring seem to be higher than those taken in summer.

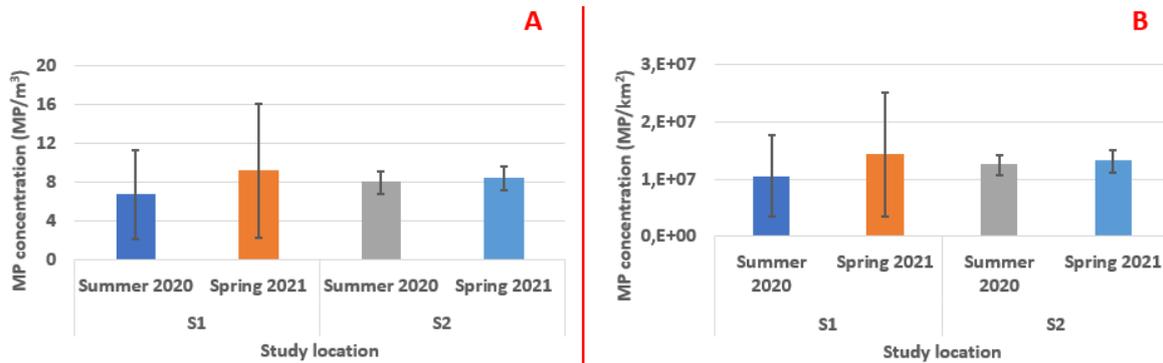


Figure 2. MP concentration in seawater in Nam Dinh at different locations and seasons, calculated by volume (A) and surface (B)

This result is higher than some reports of seawater microplastics in international publications (Table 2). The results' variability reflects the microplastic contamination level at different study sites. However, part of this disparity also comes down to research objectives, such as some studies focusing only on 1–5 mm subjects. Moreover, the concentration of microplastics also depends on the sampling method, separation method, and microplastic identification technique. For water samples, most studies used mesh sizes at the limit of 330  $\mu\text{m}$  or 500  $\mu\text{m}$ , while we used 80  $\mu\text{m}$  mesh with the goal of maximum

microplastic recovery. In addition, the method of determining microplastics also plays a vital role in influencing the reported results. There is a risk to observation in accepting microplastics. However, it is noteworthy that this method is still dominant in most of the studies (> 70%) in the world [10]. This study used two independent and empirical observations to limit risk. Note that the success rate in observation is sometimes only 6% [11].

### MP characteristics

Characteristics of MP analyzed in seawater in Nam Dinh presented in Figure 3.

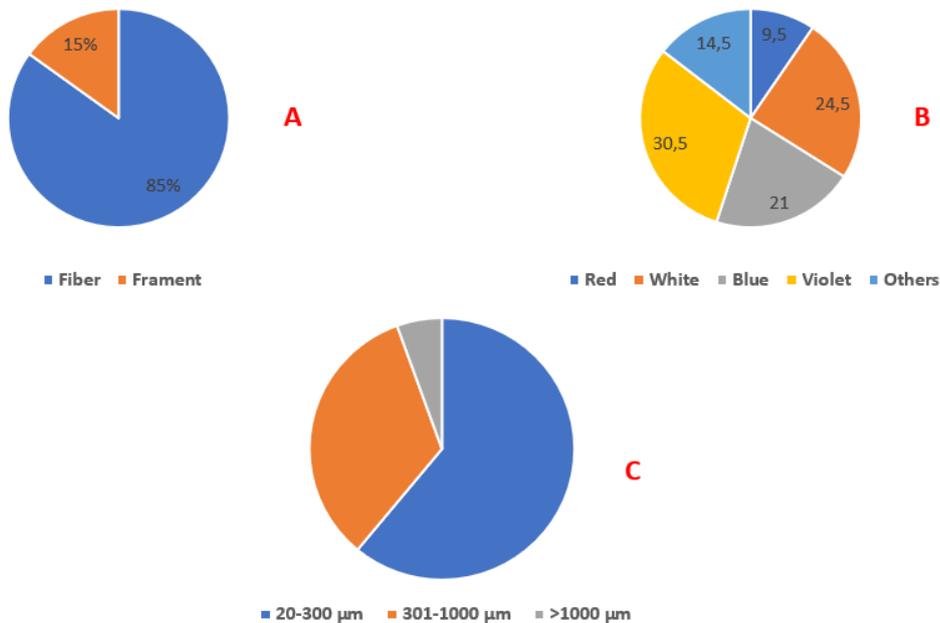


Figure 3. MP characteristics in seawater in Nam Dinh, form (A), color (B) and Size (C)

In this study, microplastic sizes were recorded from 20  $\mu\text{m}$  to 2 mm, dominated by sizes smaller than 300  $\mu\text{m}$ , despite being collected with an 80  $\mu\text{m}$  mesh. The samples are smaller than 100  $\mu\text{m}$  due to agglomeration properties. This study's predominance of

microplastics smaller than 300  $\mu\text{m}$  is also the main reason for the difference in Table 2. Besides the microplastic size factor, the difference in the time and location of study sampling also influenced the differences between studies in Table 2.

Table 2. Comparison of MP concentration in seawater in Nam Dinh with others studies in the world

Continent	Location	Time	Concentration	Size ( $\mu$ )	Reference
America	Atlantic (Northwest)	1972	3,500 MP/km <sup>2</sup>	250–500	[12]
	Atlantic (North)	1986–2008	1,534 MP/km <sup>2</sup>	> 335	[13]
	Caribe Sea		1,414 MP/km <sup>2</sup>		[13]
	Pacific (North)	1987–1988	389,800 MP/km <sup>2</sup>	53–1000	[14]
Asia	Pacific (West)	2000–2001	174,000 MP/km <sup>2</sup>	> 330	[15]
Australia	Australia		4,000–9,000 MP/km <sup>2</sup>	> 333	[16]
Europe	Mediterranean Sea	2013	243,853 MP/km <sup>2</sup>	> 200	[17]
Asia	<b>Nam Dinh (Vietnam)</b>	2020–2021	10.6–14.4 million MP/km <sup>2</sup>	> 20	<b>This study</b>

Fiber-typed microplastics are dominated among the shape textures, similar to those reported by Lahens et al. (2017) performed in water samples in the Saigon river [18]. When observing the analytical blank, some objects appear on the filter membrane. However, they are distinct from the microplastic matters in the

real sample (Figure 4). Most microplastics have prominent colors (blue, purple, red). The characteristics of microplastics allow identifying the origin of microplastics in seawater in Nam Dinh, most likely from artificial fibers, such as domestic waste (washing machines) or the textile industry.

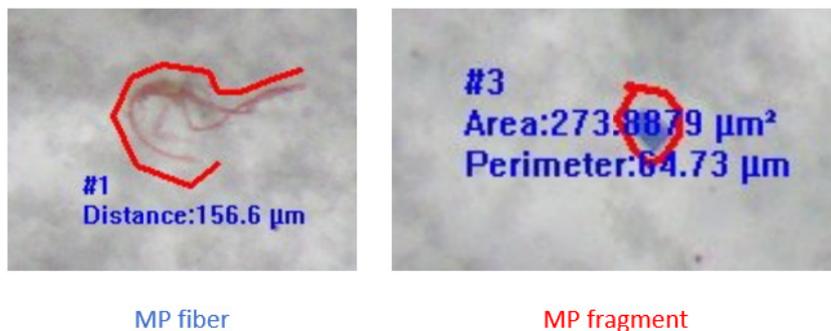


Figure 4. MPs observed under a stereo microscope, red border indicates MP position and size

Among the identified particles/fibers, Polypropylene plastic accounts for nearly 70%, followed by Polyethylene (10%). This result is similar to the production output of all plastics, especially PE and PP because they are widely used and have a short usage time. Besides two other types of plastic were also identified, including Polystyrene and Polyester (Figure 5).

The coastal zone plays a vital role in the economic structure of Vietnam, in which the

aquaculture industry stands out. Microplastic pollution in fish and bivalve mollusc farming areas can potentially affect consumer health. Research in Belgium in 2014 showed that each adult could get up to 11,000 microplastic particles per year through eating oysters and mussels [19]. While the impact of microplastics on human health remains unproven, the risk factors for exposure to this type of pollution are increasingly apparent.

The contamination of microplastics is not only through the consumption of seafood but also in daily breathing, salt, and drinking water. Recent research indicates that the human body

can ingest 73 thousand, 4.7 thousand, and 30 million microplastic particles annually through salt, drinking water, and air, respectively [20].

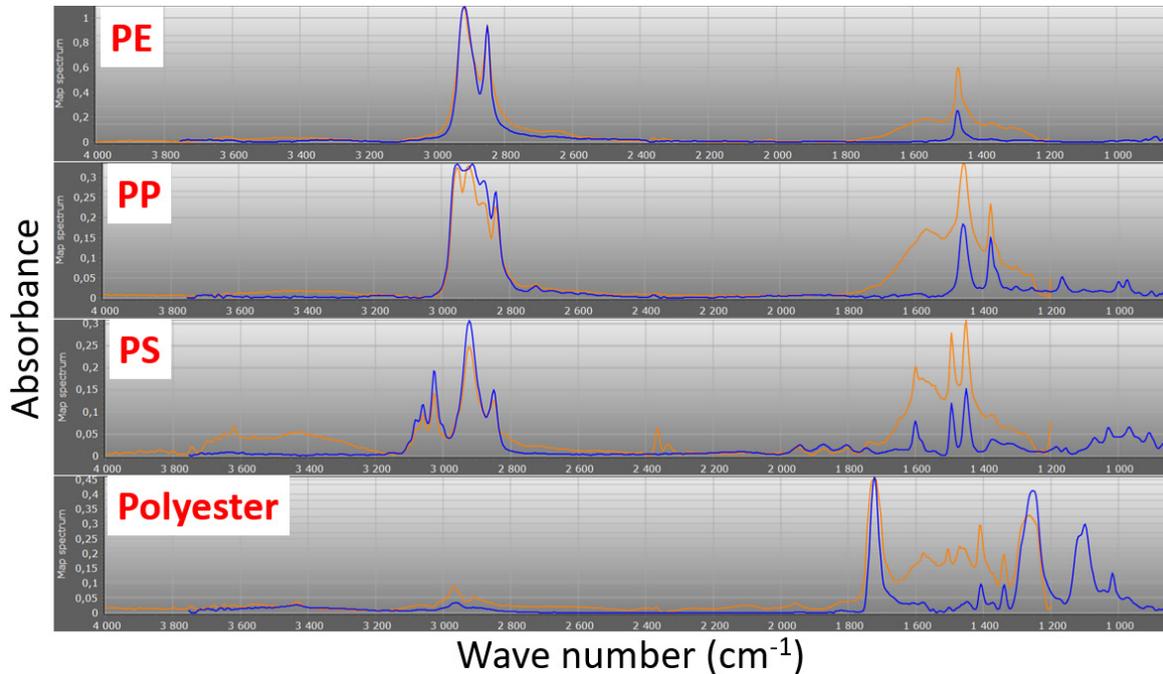


Figure 5. Infrared spectra of 4 types of microplastics in seawater samples in Nam Dinh by transmittance measurement (yellow is the measured spectrum, blue is the reference spectrum)

## CONCLUSION

The results obtained in this study indicate a high level of microplastic pollution in the coastal water in Nam Dinh, Vietnam. This report is one of the first data on microplastic contamination in Vietnam. Microplastics concentration was recorded at 10 million microplastics per km<sup>2</sup>, mainly fiber microplastics. Most microplastics are less than 100 μm in size. Plastic is mostly PE and PP (approximately 80%). Microplastics are believed to come mainly from human activities, such as textiles or domestic wastewater. However, it is necessary to do more and more deeply soon, in which determining the nature of microplastics to specify their origin is an urgent requirement.

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