TẠP CHÍ KHOA HỌC
TRƯỜNG ĐẠI HỌC QUY NHƠN

Đánh giá ban đầu về ô nhiễm vi nhựa trong trầm tích bãi biển và nước bề mặt ở khu vực ven bờ thành phố Quy Nhơn

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TÓM TẮT

Nghiên cứu được thực hiện để đánh giá mức độ ô nhiễm vi nhựa trong nước bề mặt và trong trầm tích bãi biển khu vực thành phố Quy Nhơn. Các mẫu nước và trầm tích được thu tại 4 điểm dọc theo bãi biển Quy Nhơn để phân tích. Mẫu nước được xử lý bằng SDS, Biozym ES, Biozym F và H_2O_2 30% trong khi mẫu trầm tích chỉ xử lý bằng H_2O_2 30%. Kết quả cho thấy mật độ vi nhựa trong nước bề mặt dao động từ 16,37 – 62,86 vi nhựa/m^3 và trung bình là 30,32 vi nhựa/m^3 trong khi mật độ vi nhựa trong trầm tích dao động trong khoảng 1.700 – 3.100 vi nhựa/kg trầm tích khô và trung bình là 2.400 vi nhựa/kg trầm tích khô. Nguồn nước thải trực tiếp từ thành phố được xem là nguồn gây ô nhiễm vi nhựa chính ở khu vực nghiên cứu. Chiều dài các sợi vi nhựa chủ yếu trong khoảng 300 – 2000 µm trong khi diện tích các mảnh vi nhựa tập trung ở nhóm 45000 – 400000 µm^2. Màu xanh biển, màu trắng và màu tím là những màu chủ đạo của vi nhựa dạng sợi và màu trắng, vàng và xanh biển là các màu ưu thế của vi nhựa dạng mảnh.

Từ khóa: *Vi nhựa, Quy Nhơn, sự ô nhiễm, trầm tích, nước bề mặt.*

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Baseline assessment of microplastic contamination in beach sediments and surface waters around the coastal areas of Quy Nhon city

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ABSTRACT

The study was carried out to assess microplastic contamination in surface waters and beach sediments around the coastal areas of Quy Nhon city. The water and sediment samples were collected at 4 sites along Quy Nhon beach for analysis. The water samples were treated by SDS, Biozym ES, Biozym F and H_2O_2 30% while sediments were only treated by H_2O_2 30%. The results showed that the microplastic concentration in surface water was from 16.37 – 62.86 items/m^3 with average of 30.32 items/m^3 while this in sediments fluctuated in the range of 1700 – 3100 items/kg of dry sediment with average of 2400 items/kg of dry sediment. The domestic wastewaters from the city are considered as the major source causing microplastic contamination at study sites. The length of microfibers was mostly in the range of 300 – 2000 µm and the area of microfragments was dominant in the range of 45000 – 400000 µm^2. Blue, white and purple were the dominant colors of microfibers, and white, yellow and blue were predominant for microfragments.

Keywords: *Microplastic, Quy Nhon, contamination, sediments, surface water*.

1. INTRODUCTION

Plastic pollution is one of noticable problems in the world, causing negative effects on ecosystems, especially aquatic ecosystems, and also causing potential impacts on human health. Plastic wastes released from human activities mostly end up in the seas and oceans via rivers. Under the influence of environmental factors, especially in coastal areas, such as high temperature, high radiation intensity, waves and wind, large plastic samples are separated into microplastics,[1] that have the size of from 1 µm to 5000 µm.[2] Rahman et al. reported that microplastics can cause direct effects on human health through oxidative stress and cytotoxicity, altering metabolism, neurotoxicity, reproductive system toxicity, carcinogenic, or indirect effect as a vector to transfer chemicals and microorganisms into human body.[3]

Costal ecosystems are places loaded a large amount of macroplastics and microplastics from inland as well as marine activities.[4] Therefore, microplastics can be distributed in different environments in these ecosystems. The microplastic distribution in sediments has been reported in many studies in the world, with different concentrations from the low values as of 1.3 – 36.3 particles/kg dry sediment[5] or

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48.7 – 390.7 particles/kg dry sediment[6] to high values as of 2000 – 8000 particles/kg dry sediment,[7] 5020 – 8720 particles/kg dry sediment[8] or 3000 – 18000 particles/kg dry sediment.[2] Similarly, microplastic contamination in water environment has been recorded with different densities at studied areas. This was clearly mentioned in the study of Rodrigues *et al.*[9] at the costal areas in Portugal; microplastic concentration varied from 0.015 particales/m^3 at the protected water to 0.17 particales/m^3 at urban estuary, or 2748 particles/m^3 at areas associated with submarine wreck and 4028 particales/m^3 at recreational marina. Other studies also showed the different concentrations of microplastic in waters, such as from 380 to 610 particles/m^3 at Surabaya bay – Indonesia,[10] 1660 - 8925 particles/m^3 at urban lakes in China,[11] or 10000 – 22000 particles/m^3 at delta of Manas river in China.[12] It is clear that microplastic contamination in the environment in general as well as in waters and sediments in particular has been greatly addressed by researchers in the world. However, there have been several studies carried out in Vietnam with different concentrations of microplastic recorded, ranging from 1542 to 2024 particles/kg dry sediment at Sau and Dau beach – Vung Tau[13] to 9238 particles/kg dry sediment at Da Nang beach,[14] or from 0.35 particles/m^3 water in Cua Luc bay - Quang Ninh, 2.522 particles/m^3 water in To Lich river – Ha Noi[13] to 269693 – 863005 particles/m^3 water in downstream areas of Day river.[15]

Quy Nhon is a coastal city with several advantages to develop tourism activities as well as maritime activities through Quy Nhon seaport. Along with such advantages, the coastal areas of Quy Nhon city have been greatly affected by the wastes with noticable amount of plastic waste generated from these activities as well as from the daily activities of the city's residents. Therefore, a few projects have been implemented such as the UN-GEF 2 project operated by the Quy Nhon City Women's Union in the period of 2020 - 2022 to reduce plastic waste in coastal communes and wards in Quy Nhon Bay.[16] For the successful implementation of such community project, it is essential to find scientific evidence to prove when implementing the project. For that reason, we conducted this study to give the baseline assessment on the level of microplastic contamination in the coastal areas of Quy Nhon city as well as make initial speculation about the origin of microplastics in the studied areas.

2. STUDY SITES AND METHODS

2.1. Study sites

The study area is Quy Nhon beach and corresponding coastal waters. Quy Nhon beach runs along Xuan Dieu and An Duong Vuong streets, Quy Nhon city, Binh Dinh province. This is a place for playing and swimming of residents in Quy Nhon city as well as tourists. According to statistics in April 2019,[16] the total population of Quy Nhon city was 290,053 people, with a density of 1,013.8 people/km^2. The daily human activities as well as the development of coastal tourism services, operation of Quy Nhon seaport, or fishing activities have caused certain pressures on the coastal environment.

The sites selected to collect water and sediment samples are along Quy Nhon beach, including D1 (13.7710^{0}N. 109.2448^{0}E), D2 (13.7671^{0}N. 109.2310^{0}E), D3 (13.7597^{0}N. 109.2219^{0}E) and D4 (13.7465^{0}N. 109.2145^{0}E) (Figure 1). D1 is located nearby Quy Nhon seaport and restaurants along Xuan Dieu street. D2 is also nearby restaurants, in addition of the regular wastewater drain from the city and affected from some fishing activities of local residents. D3 is the site less affected than others, separated from street by a park. D4 is located nearby a big hotel and is a place to play and swim for tourists and local residents. In addition, D4 is also affected by fishing activities and the regular wastewater drain from the city.

Figure 1. Sampling sites.

2.2. Methods

2.2.1. Sampling

Sediments and surface waters were collected in May 2021 at 4 study sites D1, D2, D3 and D4 along the Quy Nhon beach, from the Quy Nhon seaport to Ghenh Rang (Figure 1). For sediment samples, we used a tube with the diameter of 6cm and the height of 5cm to collect 5 subsamples within an area of 100 m^2, then combined them into a homogeneous sample; sediment samples were collected at the sand layer of 5cm from the surface in the intertidal zone. For water samples, the plankton net with a diameter of 50 cm and mesh size of 80 µm and a flowmeter were used to collect and calculate the collected water volume; a small boat was used to pull the net at low tide at waters about 50-100 m far from the shore. At each site, 3 subsamples were collected, and then mixed into a homogenous sample. Sediment and water samples were stored in glass containers and transported to the laboratory for later analysis.

2.2.2. Sample treatment and analysis

The water samples were treated and analysed according to the method of Emilie *et al.*[13] Firstly, each sample was filtered using the sieve with mesh size of 1 mm to discharge litters such as plants, grass but microplastics with size from 1 to 5 mm were taken and put on GF/A filters for later analysis. After filtered, the water sample was poured into the glass vessel, then added 1 g SDS and put in an incubator at temperature of 50 ^{0}C for 24 hours. Next, sample was added 1 ml of Biozym SE and 1 ml of Biozym F and placed in the incubator at 40 ^{0}C for 48 hours. Then, 15 ml H_2O_2 30% was added to the sample put in the incubator at 40 ^{0}C for 48 hours. After being treated by such chemicals, water sample was taken out of the incubator and filtered using the sieve with mesh size of 250 µm; the upper part of the sieve was tranfered into a 20 ml beaker to perform the overflow process with saturated NaCl solution. Finally, the overflowed solution was filtered on 1.6 µm GF/A filters to collect microplastics. These filters were stored in the clean petri dishes with a lid for later analysis.

Each sediment sample was dried at 55 ^{0}C within 72 hours according to the method of Quynh Anh *et al.*,[14] then mixed for homogeneity and taken 10g to treat. Next steps were almost similar to water treatment but only 20 ml H_2O_2 30% (at 40 ^{0}C for 3 hours) was added to the sample after being filtered using sieve 1 mm to remove organic matter.

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After above steps, the GF/A filters were observed using LAXS software of the stereomicroscope Leica S9i to record and analyse microplastics. The microplastics were analysed with 3 shapes as fragment, fiber and pellet according to Emilie et al.[13] All microplastics on each filter were taken photo, measured sizes and determined colours.

As limited equipment to analyze the nature of microplastics, based on the suggestion of GESAMP[18] and Emilie *et al.*,[13] we only examined microplastics with length of 300 - 5000 µm and area of 45000 – 25000000 µm^2 to ensure high reliability.

2.2.3. Data analysis

Microsoft Excel 2013 was used to analyse data and make the figures. Data analysed included concentration, size, shape and colour of microplastics found in waters and sediments.

2.2.4. Microplastic contamination control

To ensure the reliable study results, controlling microplastic contamination from surrounding environment is necessary. During the study, we cleaned the sample analysis and treatment area using alcohol before working on samples. In addition, we followed some recommendations of GESAMP[18] such as wearing cotton lab clothes and gloves, rinsing equipment with filtered water before use, etc. Moreover, during the sample treatment or analysis process, we used a control filter for each step to examine microplastic contamination. These control filters then were observed under the stereomicroscope Leica S9i to see whether there is any microplastic contaminated.

There was only one of 8 control filters contaminated 1 microplastic during observation under the stereomicroscope.

3. RESULTS AND DISCUSSION

3.1. Microplastic concentration and shape in surface waters and sediments

Microplastic concentration in surface waters varied from 16.37 to 62.86 particles/m^3, in which the lowest was at D3 and highest at D4. Microplastic concentration in sediments was from 1700 to 3100 particles/kg dry sediment, with the highest value at D2 and the lowest value at D3 (Table 1). It can be seen that microplastic concentration was different between study sites and this can be caused by different factors including human activities. Clearly, D3 is less affected by such activities than other sites and this can be the reason explaining why microplastic concentration here is lower than that at others. In contrast, D4 is the place affected from lot of activities such as tourism, fishing and especially wastewater discharge and these can lead to the higher microplastic concentration at here compared to other sites. However, microplastic concentration in sediments at D4 was not the highest and this gives a speculation that the daily wastewater source from city is the main cause leading to the high concentration of microplastic in waters at this site. This observation is even more valid when D2 is also heavily affected by the city's wastewater as at D4 and showed the second high concentration of microplastics among the 4 study sites. Thus, it can be said that there are different sources causing microplastic contamination at study area, of which the direct wastewater source from city is one of major reasons. This is also recorded by Quynh Anh *et al.*[14] when doing the research on microplastic at Da Nang beach. Besides, other activities such as restaurant services, hotel services, or fishing, etc. can be also reasons causing microplastic contamination at our study area.

The average microplastic concentration in sediments in this study (at Quy Nhon beach) is higher than that at Sau and Dau beach – Vung Tau (with 1542 and 2024 particles/kg dry sediment respectively)[13] but lower than that at Da Nang beach (9238 particles/kg dry sediment).[14] Similarly, microplastic concentration in surface waters in this study is much higher than that at Cua Luc bay – Quang Ninh (0.35 particles/m^3) but much lower than that at To Lich river – Ha Noi (2522 particles/m^3)[13] and at downstream of Day river (269693 – 863005 particles/m^3).[15]

Based on these results, it can be seen that microplastic contamination level at study areas in Vietnam is different and this can be caused by human activities such as industrial development, tourism, etc. In general, microplastic concentration at areas much affected by human activities is higher than that at less affected ones. This was reported in the research of Rodrigues *et al.*;[9] protected seas have very low microplastic concentration, and contamination level gradually increases at urban estuary, submarine wreck and recreational marina. Therefore, big cities with lots of tourism, industrial activities, etc often have high microplastic contamination level. On the other hand, microplastic concentration in waters at seas or bays is normally lower than that at rivers. This is also convinced by results of the research of Emilie *et al*.[13]

Table 1. Concentration of microplastic in surface waters and sediments.

Study sites	Microplastic concentration in surface waters (number of particles/m^3)	Microplastic concentration in sediments (number of particles/kg dry sediment)	The typical characteristics of the study sites
D1	19.35	2400	Nearby seaport and restaurants
D2	22.68	3100	Nearby restaurants; there is the regular wastewater drain from the city; there is some fishing activities
D3	16.37	1700	Less affected by human activities
D4	62.86	2400	Nearby hotel; there is the regular wastewater drain from the city; there is some fishing activities
Average	**30.32**	**2400**	

The results of this study showed that there were 2 shapes of microplastics in waters as well as sediments, that were fragments and fibers. Generally, the ratio of fibers (varied from 66.67 – 81.67% for waters and 70.59 – 95.83% for sediments) was more dominant than that of fragments (Table 2). The average ratio of fibers of 4 sites accounted for 75.51% for waters and 86.87% for sediments. The dominance of fibers is also reported in other studies such as the research of Doan Thi Oanh *et al.* (2021) (92.55 – 96.04%),[15] Quynh Anh et al. (2020) (99.2%),[14] or Filho and Monteiro (2019) (95%).[19]

Table 2. The ratio of microplastic shapes in surface waters and sediments.

Study sites	Surface waters		Sediments	
	Ratio of fibers (%)	Ratio of fragments (%)	Ratio of fibers (%)	Ratio of fragments (%)
D1	66.67	33.33	87.50	12.50
D2	81.67	18.33	93.55	6.45
D3	80.70	19.30	70.59	29.41
D4	73.00	27.00	95.83	4.17
Average	**75.51**	**24.49**	**86.87**	**13.13**

3.2. Size of microplastics in surface waters and sediments

The fibers in surface waters at 4 study sites mostly had the length of from 300 to 2000 µm. Of which, the length of fibers found at D1, D2 and D4 was mostly from 1000 to 2000 µm (accounting for 60.94%, 46.94% và 64.74%) while D3 had 69.57% of bifers having the length of from 300 to 1000 µm. When data were pooled from 4 study sites, the ratio of fibers with length of 1000 - 2000 µm was highest (55.12%), followed by this of fibers with length of 300 - 1000 µm (30.45%) (Figure 2).

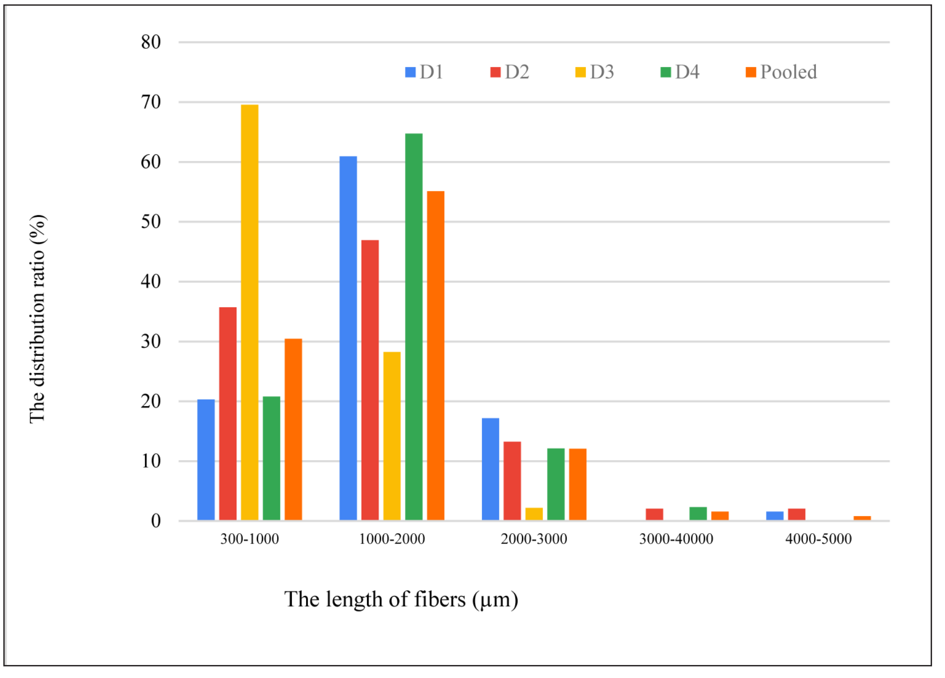

Figure 2. The distribution ratio of fibers in surface waters according to the length.

The fragments in surface waters mostly had the area of 45000 – 200000 µm^2 with the ratio of 62.5%, 59.09%, 81.82% and 75% for D1, D2, D3 and D4, respectively. The pooled ratio of fragments in this size was also highest (69.77%) in size classes of microplastics found, followed by fragments in area of 200000 – 400000 µm^2 (18.6%) (Figure 3).

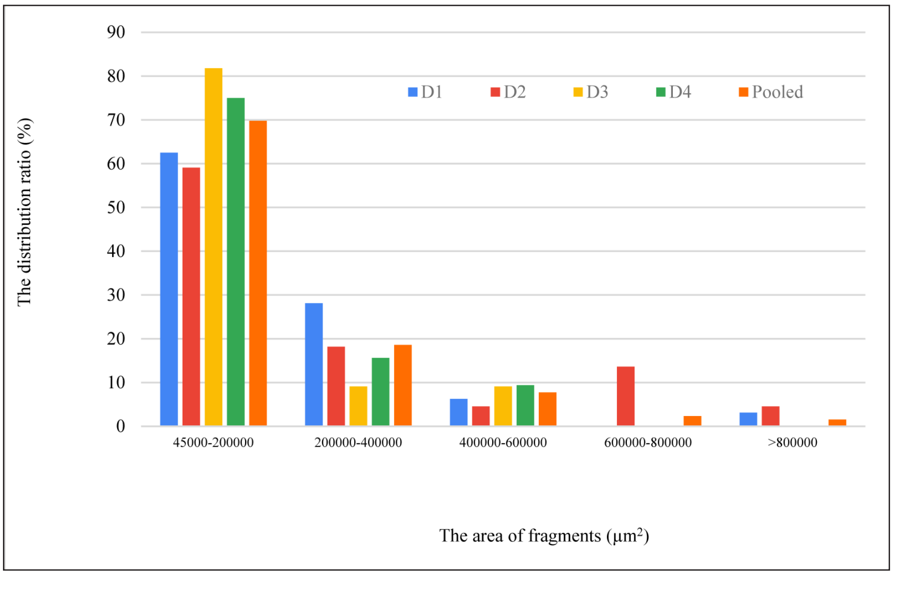

Figure 3. The distribution ratio of fragments in surface waters according to the area.

Unlike in surface waters, although there was the different size distribution of fibers between study sites, the length of fibers in sediments was only predominant in class of 1000 - 2000 µm, with pooled ratio of 42.35% while other size class had almost similar ratios (Figure 4). The fragments in sediments mostly had area in 2 classes of 45000 - 200000 μm^2 and 200000 - 400000 μm^2, in which the smaller class was dominant, with pooled ratio of 90.91% (Figure 5).

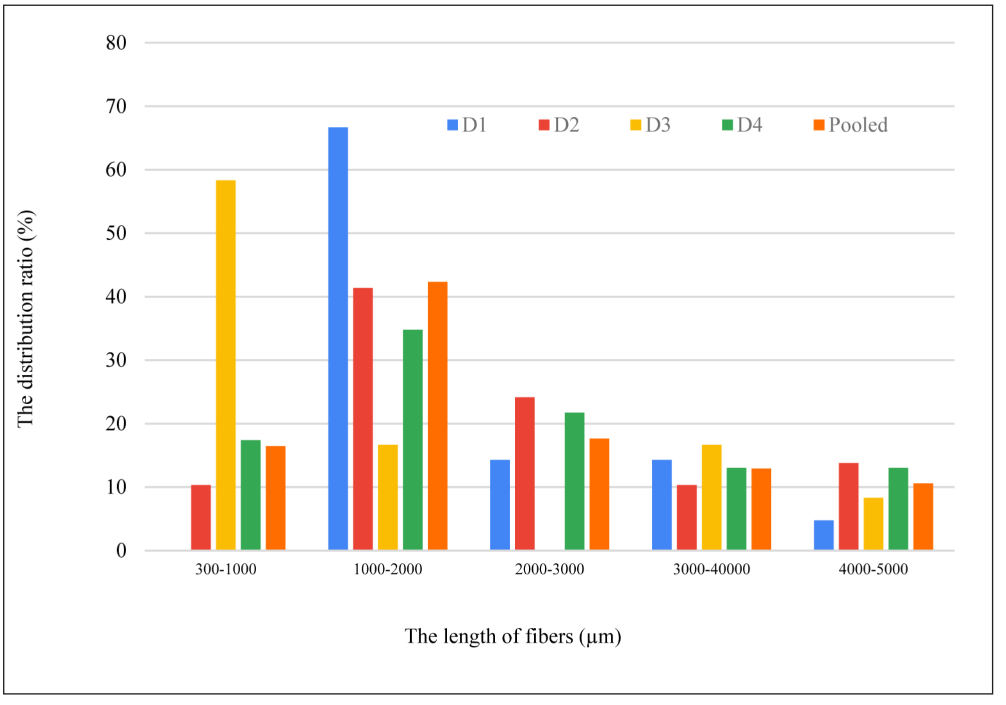

Figure 4. The distribution ratio of fibers in sediments according to the length.

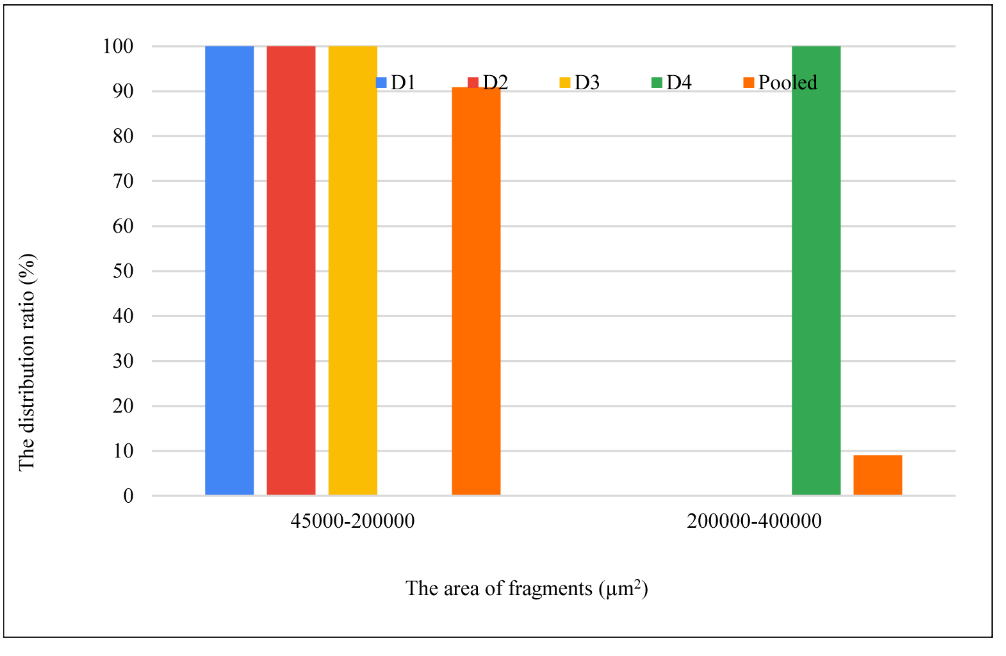

Figure 5. The distribution ratio of fragments in sediments according to the area.

In general, fibers in surface waters and sediments mainly have the length of 300 - 2000 µm and fragments mostly have the area of 45000 - 400000 µm^2. Doan Thi Oanh *et al.*[15] also reported that microplastics in waters at downstream of Day river mostly had the length of 300 - 2000 µm for fibers (accounting for 78.45 - 85.71%) and area of 50000 - 400000 µm^2 (accounting for 68.72 - 87.50%) for fragments. Similarly, the dominance in number of small size-had microplastics was also recorded in other studies.[11,14] Effects of water currents and ultra violet radiation is one of factors producing small size-had microplastics.[20]

3.3. The colours of microplastics in surface waters and sediments

The colour of microplastic fibers in surface waters was quite diverse but different between study sites. Blue, white and black were major colours at D1, purple, grey and blue were predominant at D2, purple and blue dominated at D3 while white and blue were main colours at D4. When pooled for 4 sites, it can be seen that blue was most dominant (23.5%), followed by purple (23.2%) and white (17.44%) (Figure 6).

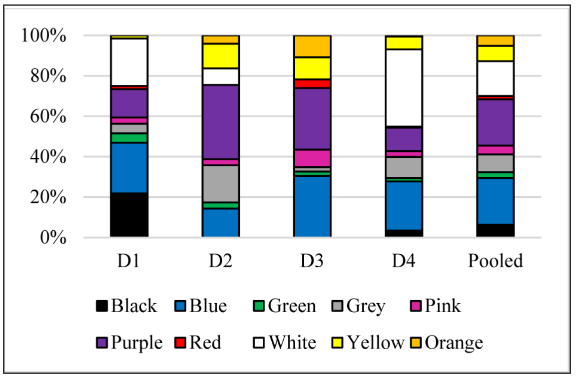

Figure 6. The colour distribution of fibers in surface waters.

The color of microplastic fragments in surface waters was also very diverse and accounted for different proportions at the study sites. Specifically, white dominated at D1 and D4, white and yellow were the dominant colors at D2 while red and orange were predominant at D3. White was the most dominant color when pooled for 4 sites (44.96%), followed by yellow (14.73%) and blue (12.4%) (Figure 7).

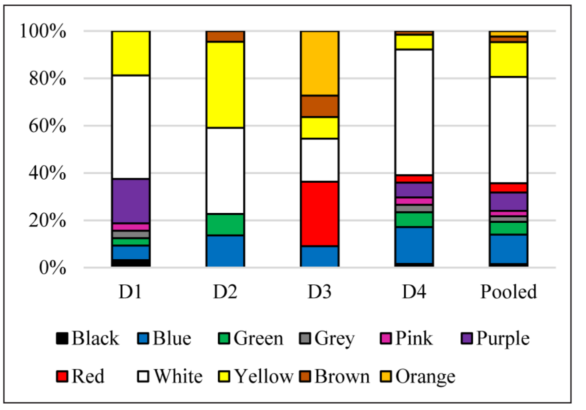

Figure 7. The colour distribution of fragments in surface waters.

Regarding to colour of microplastics in sediments, because of very low proportion of fragments, we only examined fibers' colour. Generally, the colour of fibers in sediments was less diverse than that in surface waters. The distribution ratio of colours at study sites was not similar, in which white accounted for the highest ratio at D1, D2 and D4 while blue dominated at D3. Pooled for 4 sites, it can be seen that blue was predominant colour (32.32%), followed by white (30.19%) and purple (15.47%) (Figure 8).

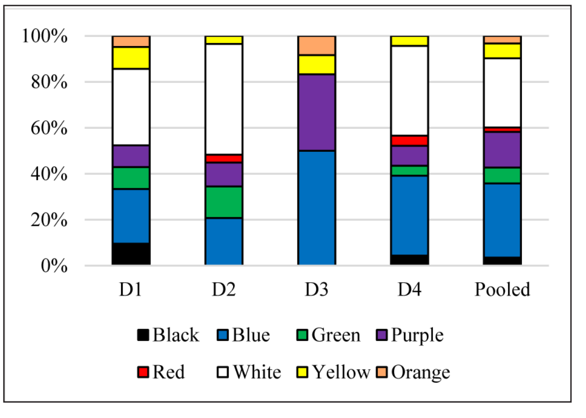

Figure 8. The colour distribution of fibers in sediments.

In general, white is the dominant colour of microplastic fibers in surface waters and sediments, followed by blue and purple. Similarly, white is also the dominant colour of fragments, but followed by yellow and blue. Not similar to our results, purple is the predominant colour of microplastics in the research of Doan Thi Oanh *et al.*,[15] followed by green and blue; black and blue are the major colours in the study of Nuelle *et al.*;[21] or blue dominates, followed by white in the study of Quynh Anh *et al.*[14] Thus, colour of microplastic in studies is different and this can be governed by different waste sources at study areas. These sources can be from garments, plastic fishing gears, packaging materials or from washing clothes through domestic wastewater.[22]

4. CONCLUSION

The microplastic concentration in surface waters varies from 16.37 to 62.86 particles/m^3 and average of 30.32 particles/m^3. The microplastic concentration in sediments is from 1700 to 3100 particles/kg dry sediments and average of 2400 particles/kg dry sediments.

The fibers found in this study mostly have the length of from 300 to 2000 µm. The fragments dominate in range of area from 45000 to 400000 µm^2.

Blue, white and purple are the dominant colours of fibers and white, yellow and blue dominate for fragments.

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