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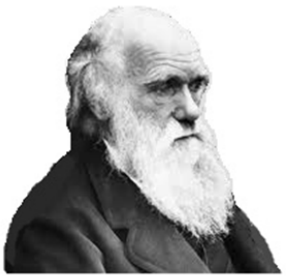

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Microplastic Abundance in Sediment in Pangandaran Waters, West Java, Indonesia

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ABSTRACT

Rapid development in the tourism sector of Pangandaraan raises various problems such as environmental degradation, environmental pollution and waste problems. Microplastic pollution in the oceans is a type of hazardous waste, with microscopic plastic particles less than 5 mm in size. Generally, easy-to-find microplastics include fragments, films, and fibers. Microplastic abundances are found in deep sea areas similar to those in the intertidal area. The purpose of this research is to know the microplastic composition which is sedimentation in various types of sediments and the factors that influence the changes to the microplastic sedimentation in the Pangandaran waters. This research uses the survey method. The most common microplastic particles in station 2 were 12.622 particles (fibers and fragments) and the lowest was found in station 4 of 1.809 particles (fiber, fragment and film). The highest number of microplastic particles trapped in mesh size sediment between 106 μm – 250 μm. Current, waves and tides are factors that cause microplastic movement in the sea. The distribution of microplastic particles is influenced by oceanography factor, density, shape and size of microplastic.

***Keywords*:** Fiber, film, fragment, microplastics, microplastic abundances, microplastic pollution, tourism, Pangandaran, waste

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1. INTRODUCTION

Approximately 60-80% of global litter consists of plastic [1-8]. Indonesia is one of the countries that produce the most plastic waste which is about 187.2 million tons after China reached 262.9 million tons [13]. Most types of plastics are not biodegradable [2] and even degradable plastics may persist for a considerable time depending on physical factors, such as ultraviolet light exposure, oxygen and temperature [25]. Plastic waste is not only a problem in the land and urban areas, but has become a problem in the oceans as well as environmental problems in Indonesia and in the world. Plastic waste has spread in marine ecosystems around the world caused by ocean currents, wind, river flows and currents [5-25].

Every day the garbage goes into the ocean, and the dominant garbage is plastic waste so the accumulation of macroplastic and microplastic waste has been caustically rising on the shore and in sediment over the past four decades [26]. Garbage that dominates in the oceans is usually in the form of microplastic waste. Microplastics are plastics of microscopic size, namely plastics with a diameter of not more than <5 mm. Microplastics in the sea are divided into primary microplastics and secondary microplastics [7]. Primary microplastics are pure plastics of microscopic size that enter the sea area directly caused by negligence in the handling process, whereas secondary microplastics are huge plastics that degrade into small plastics and enter water areas, primarily the sea. (Beberapa jenis mikroplastik dapat dikategorikan berdasarkan bentuknya, diantaranya yaitu fragment, fillament, film, foam, pellet dan granule) [16, 32].

Microplastics have a huge impact on the marine environment due to the bioaccumulation process and their involvement in the marine food chain [9] and small microplastic sizes cause organisms to regard microplastic as food [5]. The effects of organisms and other particles make microplastic slowly begin to sink and settle at the bottom of the waters over time [30]. Microplastic when entering the marine environment can be directly micro-sized, as in cosmetic wastes and face washing soap [18], or due to changes to fragments of very small size [3]. Microplastic waste in the marine environment is found either on the surface or in basic sediments. Lighter microplastic masses than the densities of sea water cause the microplastic to float on the surface when it enters the water.

Coastal pollution problems will have an impact on the destruction of living organism, including oil pollution, heavy metal pollution, pesticides and garbage. This type of pollutants is the main problem in some coastal tourist locations in Indonesia. It takes a long time, the plastic to break into small pieces into microplastic, because it depends on the type of microplastic and the breakage of plastic material is caused by mechanical forces (eg. waves) and /or photochemical processes triggered by sunlight, especially ultraviolet rays, facilitating fragmented microplastic [28]. Microplastic abundance is found in deep sea areas similar to those in the intertidal area [30].The intertidal area is strongly influenced by the pattern of sea tides and low tides. As a result of changes in tidal conditions and sea water receding conditions and due to coastal wave activity, the physical condition of the coast will always change both temporally and spatially. Temporal changes make the physical condition of the beach will vary within hours, days, months and years. Spatial changes make the physical condition can change in various places even if the distance is close enough.

Pangandaraan is one of the most famous tourist destinations in West Java. This tourist destination has grown and has the potential to be strategic enough to encourage the development of the region and as a contributor to local and state revenue. Microplastics in the environment can be a problem if lead to microplastic contamination in the waters of the future, so it's feared

it could be a threat in many ways implications for social conditions as well environment. The purpose of this research is to find out the microplastic composition which is sedimented on various types of sediments in the waters of Pangandaran waters.

2. METHODOLOGY

This research uses survey method. Selection of microplastic sediment sampling point using random sampling method. Site determination using purposive sampling method with 50 × 50 cm quadrant fitting [4]. In each quadrant, 3 sediment samples were taken using random sampling method. Microplastic abundance and its distribution were analyzed using descriptive statistics.

Physical parameters : bathymetry, current, waves height, and tidal. Microplastic Composition. In this study used the method of separation density, by making use of solvent for observation microplastics in sediments. The separation of microplastic particles (0.045-5 mm) from the sediment was carried out by several stages: (a) drying, (b) volume reduction, (c) separation of density, (d) filtration, and (e) visual sorting. Microplastic particles are visualized using a microscope and grouped into four types, namely film, fiber, fragments, and pellets. The parameters taken were abundant (particle kg-1 dry sediment) [12].

Large Size of Sediment Granules. Samples were separated from each sieve size until clean and then weighted with good method.

$$\text{Sediment Weight} = \frac{\text{Weigth of Sieve}}{\text{Total Weight of Sample Sieve}} \times 100\ \%$$

3. STUDY AREA

Location of astronomical Pangandaran between longitude 108º40' E and latitude 07°43' S. The total area of Pangandaran Regency is 168,509 Ha with an area of sea of 67,340 Ha. Pangandaran Regency has a coastal length of 91 Km. The study was conducted in May 2017 - November 2017 (Figure 1 & 2).

4. RESULT

4. 1. Bathymetry

The bathymetry of Pangandaran waters varies between 5 - 200 m. The depth increases towards the sea and away from the coast Bathymetry is one of the important factors in distributing microplastic particles. Bathymetry can affect the bending or forwarding the wave propagates into the beach and high waves coming in. The wave propagates from the sea in the beach will be undergoing changes due to a change in form of the bathymetry. The bending direction and wave propagation closely related to transport of microplastic and particle distribution. When waves approach the beach, the lower part of the wave movement that borders on the sea floor will slow down due to friction. The friction that occurs will lead to microplastik particles suspended in the water column again and deposited elsewhere.

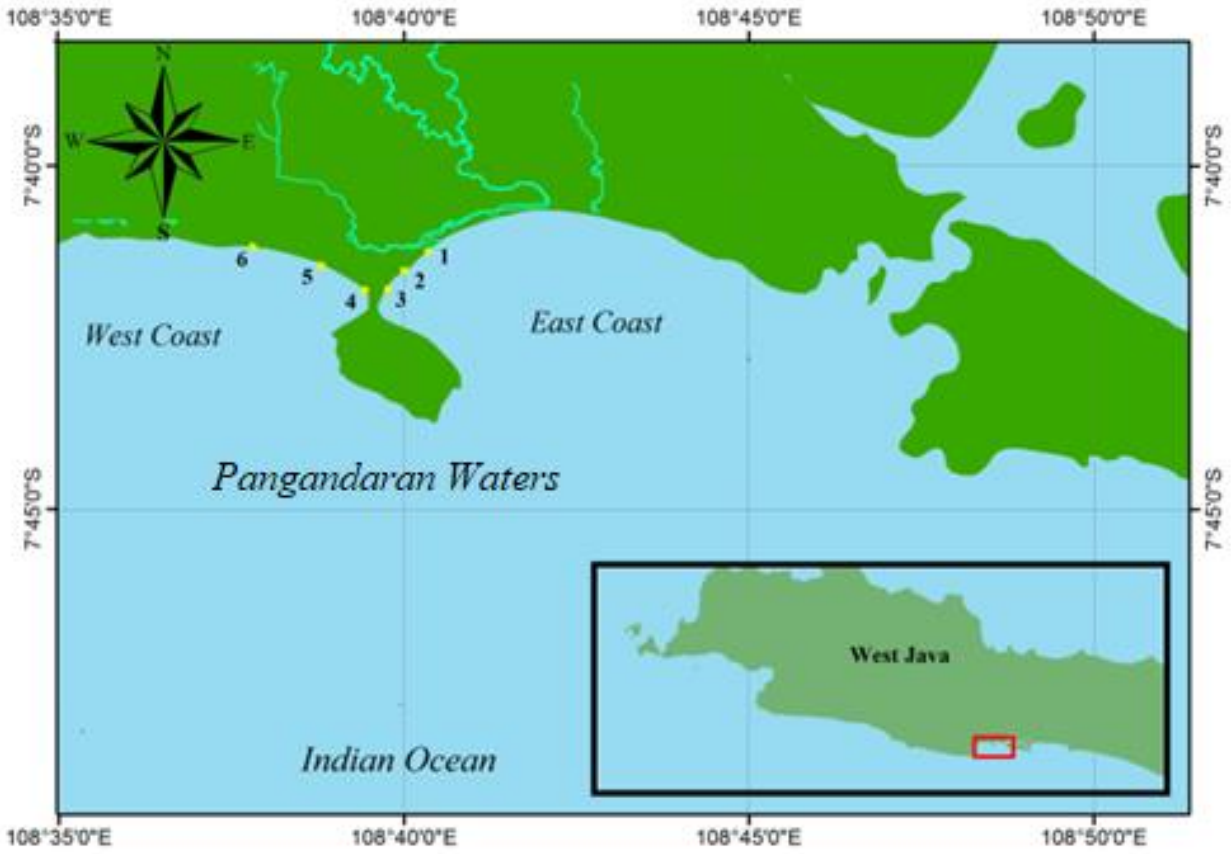

Figure 1. Study Area

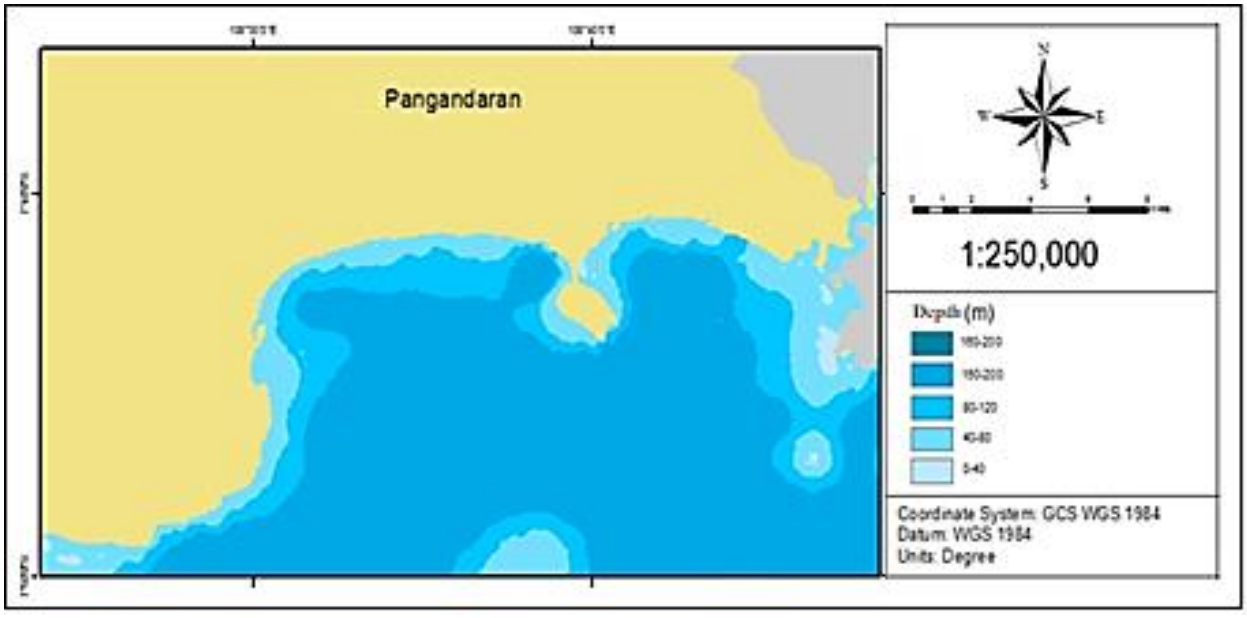

Figure 2. Bathymetry in Pangandaran Waters

4. 2. Current

Indonesian waters have a high surface current pattern influenced by the southwest monsoon (December-March) and southeast monsoon (June-September). The influence of these two monsoons is clearly visible on the South Coast of Java. In the southwest monsoon the surface currents in the South Sea of Java move from West to East or eastward, to the southeast monsoon the currents move from East to West. The pattern of the average monthly current movement is generated by the tides and the wind, where the more dominant is the influence of wind movement. Transitional Season I (April - May) where there is a transition of wind from east to west. The direction of the flow to the West is quite small due to the relatively small wind presure. The direction of the dominant currents in Pangandaran waters is to the northeast, with velocity ranging from 0.17 to 0.32 m / s (Figure 3).

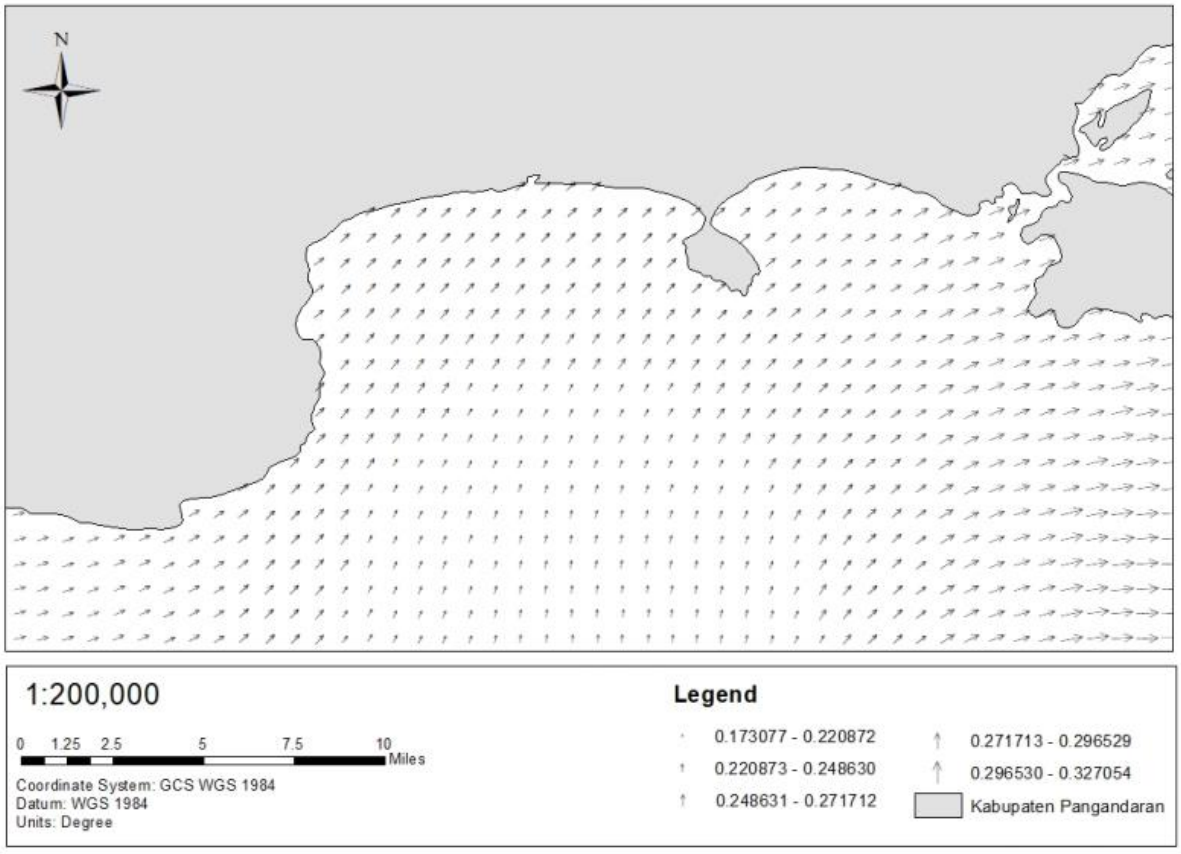

Figure 3. Current in Pangandaran Waters

4. 3. Wave Height

Waves are the dominant physical factor in the waters of the South Coast of West Java, because most of these waters have a considerable wave height in offshore waters between 1.5 - 5 m, so that almost certainly with high wave conditions this will hamper the efforts of aquaculture and potentially cause danger to coastal tourism.

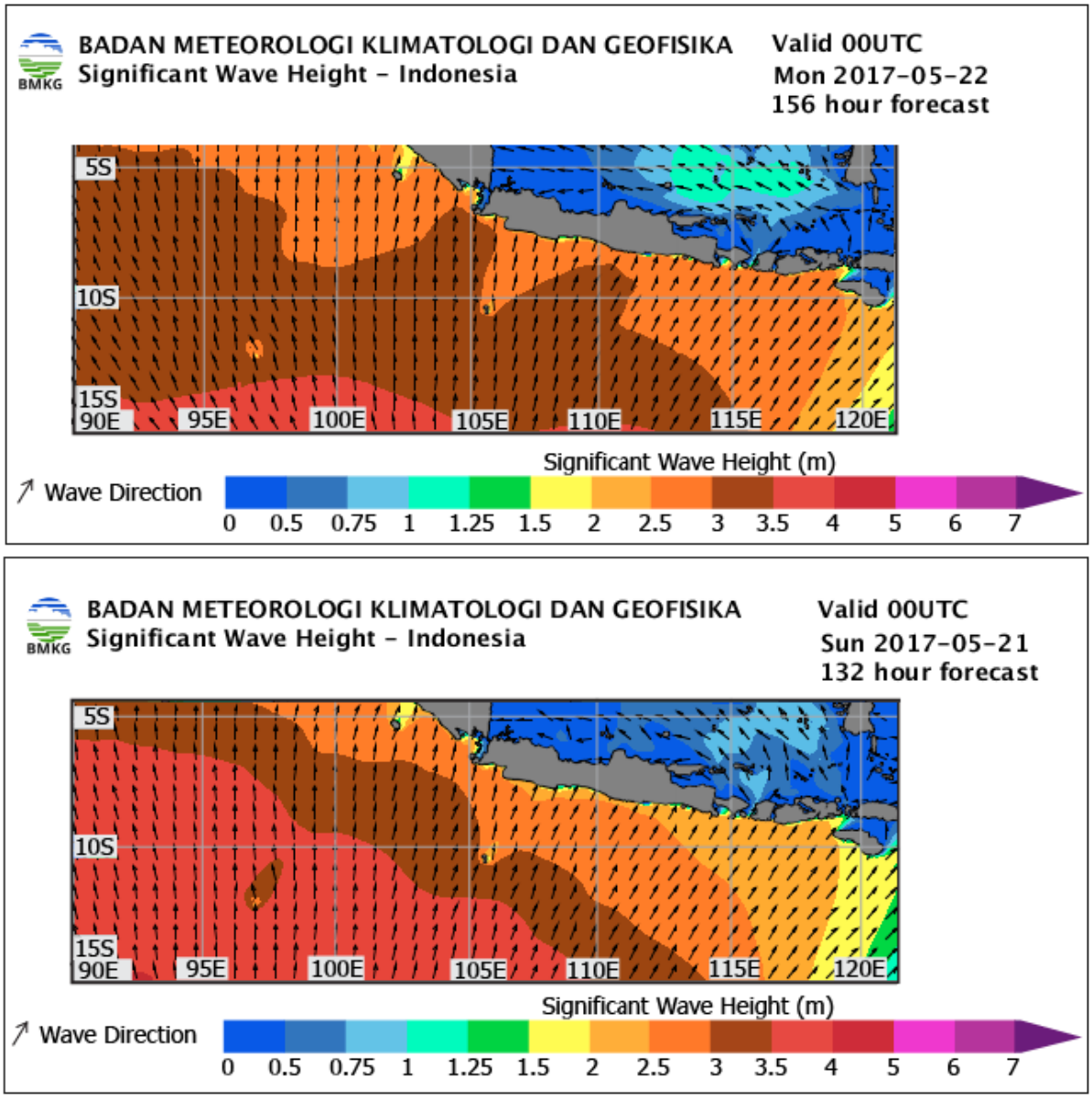

Figure 4. Wave Height in Pangandaran Waters

Based on its source, the waves on the south coast can be distinguished from the type of swell waves and wind waves. Swell is a creeping wave that originated from the Indian Ocean region, which then spread to the coast. In general, swell is higher than wind, waves (wind waves). High waves occur when there is a superposition swell and wind wave. Wind wave height is basically relatively small for coastal areas, especially in bay waters ranging from 95 to 105 cm. However, for open sea with the form of narrow expanse zone that many exist in a number of locations is very possible for the occurrence of massive waves to the shore. The wave will break near the beach with the wave height is still large, so that energy to the beach is still relatively strong.

4. 4. Tidal

Type of tidal in Pangandaran waters was semidiurnal tides. In general, most areas have two high tides and two low tides each day. In one day there are two highs and two lows, accompanied by differences in periods and sea level. The highest tide is 0.962 m, while the lowest ebb is 0.946 m.The occurrence of two high tides and two low tides will experience twice the current direction change in one day. The speed and direction of current and sediment grain size can affect the movement of sediment. The larger grain size of sediment that required current velocity also will be even greater for transporting sediment particles. Knowledge of the tides are very important to the distribution pattern of observations of sediment and sedimentation formed within the environment of deposition (Fig. 5)

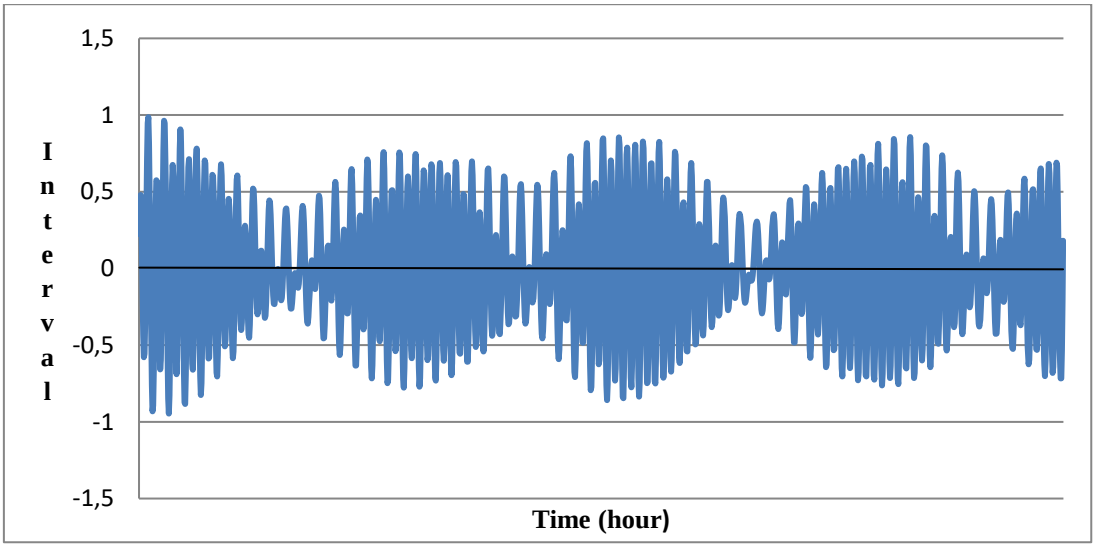

Figure 5. Tidal Phase in Pangandaran Waters

4. 5. Microplastics Abundance

The results of the identification of microplastic particles in coastal waters of the west and east of Pangandaran are seen in Table 1. Microplastic particles trapped in most sediments found in station 2 are 12,622 particle/kg consisting of fibers and fragments. The existence of the lowest microplastic particles found in station 4 is 1,809 particle/kg consisting of fiber, fragment and film. Microplastic particles in surface sediments in the East Coast of Pangandaran are more numerous when compared to the microplastic particles found in the West Coast of Pangandaran. The plastic waste that decomposes into the invisible fiber is immersed at the bottom of the ocean stuck with the sediment. Microplastic is abundant in all sediment samples with grain size of 106 μm - 250 μm and most are blue, green, red, orange, black, and transparent. The properties of sediment transport affect the sediment itself, which affects the formation of sedimentary structures that are formed. Physical properties such as the range of sizes, shapes and specific gravity of the sediment grains are affected by processes ranging from erosion, transport to deposition.

Microplastic distribution in the ocean is not known for certain. Oceanographic factors such as currents, waves and tides are factors that cause microplastic movement in the ocean.

Current, waves and tides may result in resuspension of the basic particles. The distribution of microplastic particles is not only influenced by oceanographic factors, but is also influenced by the properties of the microplastic particles themselves, such as the density of the shape and the size of the microplastic. Microplastic density is a factor affecting the distribution of microplastic particles. The frequently used plastic density ranges from 0.85 - 1.41 g / ml. Polypropylene and polyethylene (LDPE, HDPE) have densities of <1 g / ml, polystyrene, nylon 6, polyvinyl chloride (PVC) and polyester terefitalate (PET) have a density> 1 g / ml. Microplastic can be distributed through the water column.

Plastics with low densities will occupy the surface and hover in water columns as well as high density plastics found at the bottom of the water. Pangandaran waters is located in the South Sea of Java which is a coastal area bordering the Indian Ocean and has dynamic oceanographic characteristics. When samples are obtained, the plastics are separated from the sediment by separating the dense, filtration, sieving and visual identification. Particle characterization is used in the morphological description, source, type, shape, color, chemical composition and particle degradation stage. type of film is made of PE or polyester which has a low density of 0.91–0.96 g/cm 3 compared to water so that it floats on the surface of the water. Its presence in Pangandaran waters is suspected to be due to being carried by currents, waves and tides into the sea.

Table 1. The Abundance of Microplastic Particles in Pangandaran Waters.

Mesh size	Station 1			Station 2			Station 3		
	Fiber	Fragmen	Film	Fiber	Fragmen	Film	Fiber	Fragmen	Film
4,75 mm	0	0	0	0	0	0	0	0	0
2 mm	0	0	0	0	0	0	0	0	0
850 µm	0	0	0	0	0	0	0	0	0
425 µm	0	0	0	5	0	0	59	22	0
250 µm	1608	1624	0	4264	703	0	2963	1116	0
180 µm	874	54	0	2377	883	0	523	197	0
150 µm	959	200	0	1405	645	0	860	324	0
106 µm	1270	394	0	1480	708	0	1167	440	0
90 µm	0	0	0	0	0	0	0	0	0
75 µm	14	2	0	44	16	0	70	26	0
< 75 µm	42	10	0	67	25	0	27	10	0
Jumlah	4768	2284	0	9641	2980	0	5670	2136	0
Total	7052			12621			7806		

Mesh size	Station 4			Station 5			Station 6		
	Fiber	Fragmen	Film	Fiber	Fragmen	Film	Fiber	Fragmen	Film
4,75 mm	0	0	0	0	0	0	0	0	0
2 mm	0	0	0	1	0	0	0	0	0
850 µm	1	0	0	2	0	0	0	0	0
425 µm	7	2	0	15	4	0	0	0	0
250 µm	547	145	24	579	153	25	203	54	9
180 µm	26	7	0	125	33	5	129	34	6
150 µm	405	108	18	342	91	15	475	126	21
106 µm	368	98	16	529	140	23	627	166	27
90 µm	0	0	0	0	0	0	0	0	0
75 µm	21	6	0	15	4	0	11	3	0
< 75 µm	9	2	0	7	2	0	6	2	0
Jumlah	1384	367	58	1614	428	69	1451	385	63
Total	1809			2111			1899		

5. DISCUSSION

Microplastics are found in the form of pieces that differ according to shape, size, or color to the natural particulates around them, and what is often reported is microplastics with fiber types that are blue or red [12]. This type of fiber has a characteristic that is shaped like fibers or like fishing nets. In general, this type of fiber is easy to find because of its use as a basic ingredient in the manufacture of clothing, clothing fibers, fishing nets, and in the manufacture of household appliances. Microplastics in the form of fiber probably originate from the fisheries sector from the use of fishing nets and ropes [34] or originate from laundry washing spread through fresh water and municipal waste disposal [6, 34]. This type of film has the characteristic of being shaped like a sheet or plastic shards, generally used as material for making plastic bags or plastic packaging. This type of film is usually caused by fragmentation of plastic bags but may originate from vinyl used in agriculture [34]. Fragment type microplastics have the characteristics of being in the form of shards produced from waste such as bottles, jars, mica folders, as well as small pieces originating from PVC pipes.

The abundance of microplastics in waters is influenced by anthropogenic and environmental factors (surrounding environmental conditions, currents, and weather conditions) [20]. Microplastic particles are distributed and may migrate from distant locations, but there is a correlation between microplastics and population density and indicates that these

plastic particles originate from terrestrial sources with intensive anthropogenic activity [22] and in the vicinity of the most urbanized and industrialized areas even in these areas. has a low population density [23].

The amount of microplastic increases coincides with the direction of ocean currents. Ocean currents and wind are important factors that regulate the spread and distribution of microplastics on the surface [21]. Other factors that affect the concentration of microplastics in the oceans are wind speed, wind mixing, and sea surface currents [10]. Ocean currents can transport and distribute microplastics far from their source [11, 29]. The process of transporting and distributing microplastics can reduce the concentration of microplastics [31] and concentrate or deposit microplastics in marine circulation centers [14]. In addition, high-density microplastics have been found in surface waters which may be influenced by factors that affect turbulence and vertical mixing, such as tides [29].

Apart from various biological actions, microplastics in seawater eventually sink into the ocean when they lose their buoyancy over time, thereby increasing the concentration of microplastics in sediments. Microplastics are abundant in areas with weak current strength and in sediments. In addition, the amount of microplastics in seawater shows a positive correlation with the amount of microplastics in sediments [33, 34].

Presented data on tourist visits, population and amount of waste production in Pangandaran Regency between 2017 – 2020. The number of tourist visits and population affect the amount of waste production (table 2). The increase in population is closely related to the waste produced, as well as tourism activities.

Table 2. Tourist Visits, Population, and Waste Production in Pangandaran District

	2017	2018	2019	2020
Number of Tourist Visits[1]	2.536.962	3.578	3.227.296	3.604.128
Population (People)[2]	395.098	397.187	399.284	401.493
Amount of Waste Production (ton/day)[3]	185,83	171,21	250,23	252

Source: 1. https://jabar.bps.go.id; 2. https://pangandarankab.bps.go.id;
3. https://opendata.jabarprov.go.id;

6. CONCLUSIONS

The wave height is quite large in the offshore waters between 1.5 - 5 m and the mean current velocity 1.0 m / s. The most common microplastic particles in station 2 were 12,622 particle/kg (fibers and fragments) and the lowest was found in station 4 of 1,809 particle/kg (fiber, fragment and film). The highest number of microplastic particles trapped in mesh size sediment between 106 µm – 250 µm. Current, waves and tides are factors that cause microplastic movement in the sea. The distribution of microplastic particles is influenced by oceanographic factors, density, shape and size of microplastic. Microplastic density is a factor affecting the distribution of microplastic particles.

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