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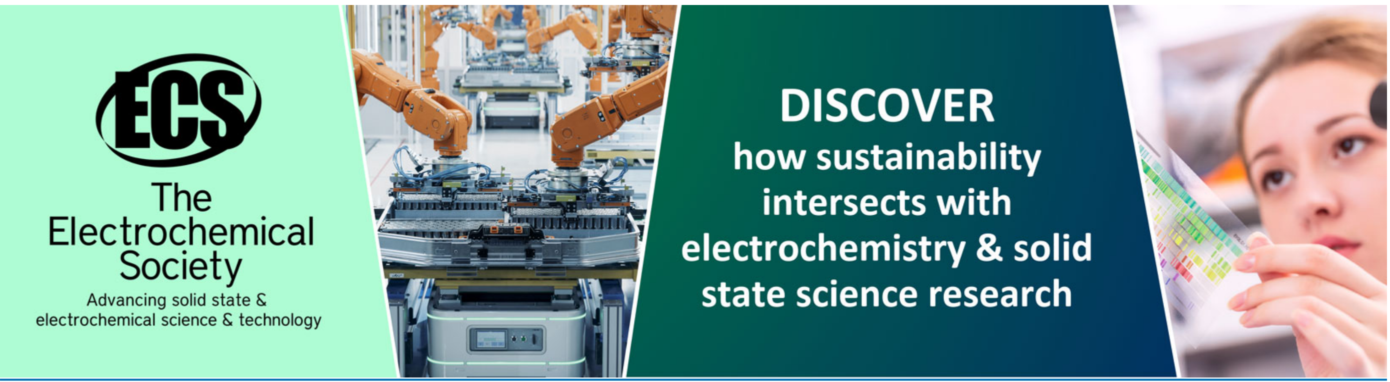

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Seasonal effect on the spatial distribution of macro debris in Tunda Island, Banten

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Abstract. The small island coast is an area that is vulnerable to environmental problems. Debris problems occur in some areas of Tunda Island with low human activity, due to current and wind factors that can distribute the debris. The speed and direction of wind and currents in Indonesia are influenced by the seasons, so the seasons have an influence on the accumulation of debris in a place. This study aims to determine the effect of the season on the distribution of debris and potential sources that influence the presence of debris on the coast of Tunda Island, Banten. This study uses MIKE 21 software to determine current and wind patterns and movement of macro debris particles. Based on season research, it influences the pattern of macro debris distribution in this area. In the east season, the increase in the litter is 9 kg from the weight of the debris in the west season. Also, there is an increase in debris in several categories including the most likely to find items, fishing gear, packaging material, small pieces trash, and base wood materials. The potential source that affects the presence of debris on the coast of Tunda Island, Banten is Muara Ciujung.

1. Introduction

Coastal areas have different characteristics areas due to the influence of land and sea, making the region vulnerable to disasters and environmental problems [1][2]. One of the environmental problems that affect the condition of the coastal area is debris. Tunda Island is a small island located in the North Sea of Java. Tunda Island has a high debris problem. Debris problems correlate with the population density of the region. However, it turns out that this problem does not only occur on the coast of a large island with a high population density, but a small island coast with a low population density also experiences the same problem. Debris in coastal areas is also referred to as marine debris and is one of the complex problems faced [3]. In addition to human activities, the presence of debris in a coastal area is influenced by the oceanographic conditions of these waters. That is because the debris can be transported by ocean currents from one place and will accumulate in the middle of the sea [4][5][6] or the coast.

The effect of current on the movement of debris on the surface by several studies. Based on several studies the high amount of plastic debris on Easter Island is indicated that the debris is transported by surface currents to the South Pacific Subtropical Gyre which will then accumulate there [5][6][7]. The wind is a very influential factor in the abundance of debris on an island [8][9][10][11]. The currents and winds in Indonesia are greatly influenced by the season system. The wind is the driving force of surface currents so that the direction of the current will be the same as the direction of the wind. So that the movement of debris carried by the flow is closely related to the conditions of the seasons that occur. The difference in conditions will also affect the direction and speed of surface currents.

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Tunda Island is one of the small islands in Indonesia, located in the Java Sea. Tunda Island has a high potential value because it has abundant marine biological resources. Tunda Island is usually used as a tourism destination. However, the development and sustainable management of coastal areas on this island have not been realized properly. The study of the influence of seasons that cause differences in direction and speed of wind and currents around the waters of Tunda Island. Then the high and low of human activity around the coast of Tunda Island. These two things are factors that will affect the distribution of waste around Tunda Island. Information about the distribution of waste on the coast of Tunda Island can be used as a basis for overcoming the problem of waste in small islands of Indonesia

2. Method

The location of sampling carried out on the Tunda Island, Banten. Samples were taken at two different seasons. The first sampling was conducted in the west season, exactly from 12 to 14 February 2018. Then the second sampling was conducted in the east season on 10-12 August 2018.

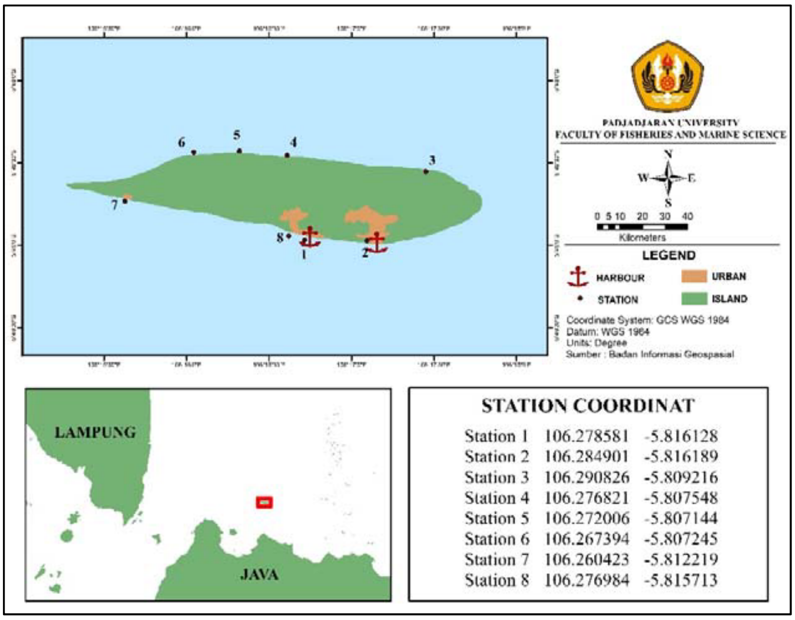

Figure 1. Research map.

The method used is purposive sampling and descriptive analysis. The purpose sampling method is used to determine the data collection station. Sampling was carried out in the Tunda Island coastal areas which were not submerged in water or the beach. The extent of the sampling area starts from the highest tide to the area that is not affected by the tide. Samples were taken using a 100-meter transect starting from the highest tide to an area that is not tidally affected. Sampling included types of macro debris and debris weight. There are 8 points used as stations around Tunda Island. The image of the data collection station can be seen in Figure 1. After sampling the debris is then calculated based on the specified category to determine the distribution of debris. There are 7 categories of debris based on the modified ICC form found in the field, namely category a) Most frequently found (Most Likely to Find Items), this type of debris is the most frequently found category because it is often consumed by the public every day. The types of debris that fall into this category are cigarette butts, plastic food wrappers, cups and bottles (plastic, cans), straws, cutlery, glass bottles, and paper bags, b) Fishing Gear, c) Packaging Material, d) Personal Hygiene (debris category consisting of condoms, diapers, injections and medicines, tampons. This category of debris is very rarely found because of its sensitive and dangerous. This rubbish is personal and only a few people can consume it), e) Other Trash, f) Tiny Trash Less Than 2.5 cm, g) Base Wood Material.

The descriptive data analysis method aims to make a description or factual and accurate description of the facts and the relationship of oceanographic conditions and the environment around the location with the weight and type of sample found at each station. Oceanographic parameters measured are bathymetry, tides, currents, and wind.

This study uses the numerical modelling of hydrodynamics and particle trajectories. Particle trajectory modelling is done by determining the possible points is one of the sources of debris in Tunda Island. Spatial and temporal visualization of the modelling results is used in describing current circulation patterns, sea level elevations, and macro debris movement models. The results of the modelling of macro debris movement will be related to the type and weight of debris in Tunda Island to get the spatial distribution of macro debris on Tunda Island, Banten

3. Result

3.1. Wind conditions

West Season happen in December, January, and February with the direction of movement from west to east. The wind is moving from Asia to Australian continent. While East season is the wind that moves from east to west. The wind came from Australia to Asian which brings dry air [14], Wind East season occurs in June, July, and August.

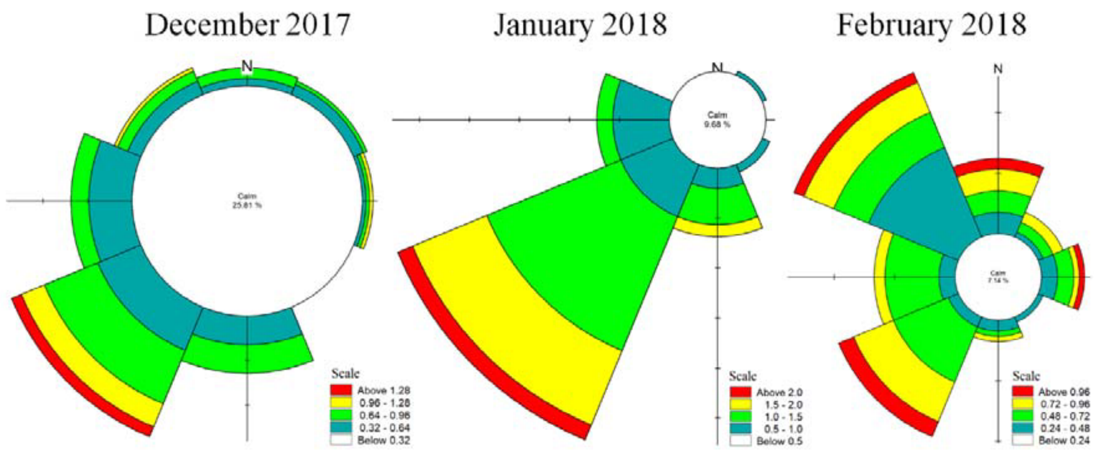

Figure 2. Wind Rose West season

Figure 2. Shows the speed and direction of the wind that occurs in the west monsoon. The speed of wind direction in this season ranges from 0.24 - 2 m/s with the dominant wind speed ranging from 0.64 - 1.5 m/s. The highest wind speed occurred in January with a value of 2 m/s. The direction of the wind in the west monsoon predominantly moves from the southwest. The wind direction anomaly is caused by the phenomenon of MJO (Madden Julian Oscillation) in the southwest part of Tunda Island, precisely in the Sunda Strait waters. MJO will form cumulus clouds that can inhibit incoming solar radiation, by reflecting 70-90% of the radiation [15]. This phenomenon results in lower OLR (Outgoing Longwave Radiation) values in the Lampung and Sunda Strait areas of 180-190 W/m^2 compared to the waters of the Java Sea. The OLR value of the Java Sea waters precisely to the north of Banten shows a value of 190-200 W/m^2 [16]. The OLR value is proportional to the temperature value. This resulted in temperatures around Lampung and the Sunda Strait lower than Java. So that the wind will move from the strait toward the northern waters of Java. That is because the pressure in the Sunda Strait is higher than the Java Sea.

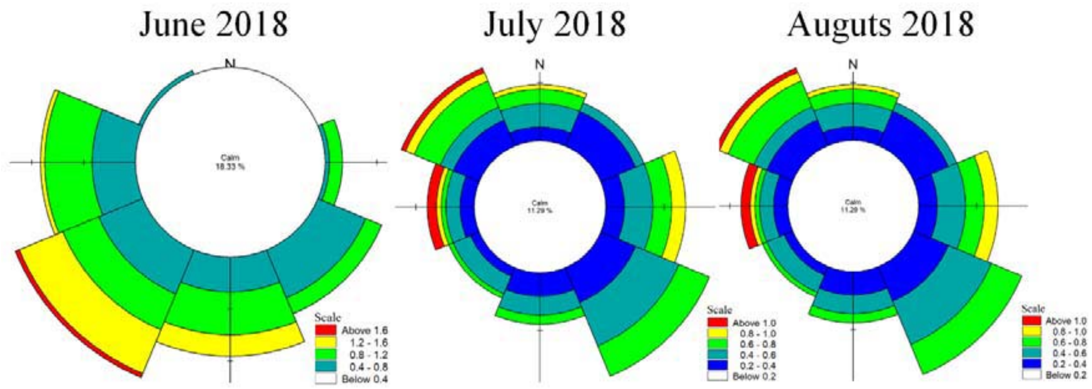

Figure 3. Wind Roses East Season

Figure 3 shows the movement of the wind in the East Season. Wind movements in the East Season tend to come from the southwest, northwest, and southeast with wind velocity ranging from 0.2 - 1.6 m/s. The highest wind speed occurred in June with a value of 1.6 m/s. Based on the analysis in June there is still influence from the west transition season so that the wind direction tends to come from the southwest. In July August the wind that moved from the northwest due to the influence of MJO which caused the variability of OLR values in Sumatra and Java. Lampung and Java OLR values are between 5 - 25 W/m^2, while northern Sumatra OLR values are -15-5 W/m^2 [17][18]. The OLR variability results in temperature differences between Java and northern Sumatra. So there is a turn in the direction of the northeast trade winds moving in the northern Sumatra region. While the wind that moves from the southeast is the east monsoon.

Based on the processing of wind data on Tunda Island, the dominant wind affecting Tunda Island is the West and East Season Winds. The dominant west monsoon movement originating from the southwest and northwest of Tunda Island results in high accumulation of rubbish on the east coast of the south, due to the influence of the wind that carries sea litter around the northern waters towards the south coast. While the wind that moves from the northwest causes the accumulation of debris on the south coast. The wind will affect the direction of currents around the southern coast, the wind will increase the speed of surface currents that head towards the southern coast of Tunda Island. So that the accumulation of marine trash on the south coast will be faster. Settlements in the southern part increase the amount of debris in the south. That is because the high level of human activity around the coast will increase debris production on the coast. The movement of rubbish from residential areas to the coast is influenced by local winds, namely the sea breeze. That is because of the movement of the wind from land to sea. So that debris thrown away in the settlement will be carried by the wind to the coast and cause an increase in the quantity of debris on the south coast. During the east monsoon, the dominant wind moves from the northwest and southeast. The movement of the wind, like the previous season, will have an impact on the accumulation of debris in the north and south. Wind from the northwest will increase debris accumulation on the north coast. While the winds from the southeast will cause the accumulation of debris on the southern coast. Debris accumulation on the north coast is lower than in the south, because of the distance of the north coast which is far from the settlement and residents' activities. Besides that, the distance of the north coast of Tunda Island is far from the activities of the Big Islands.

3.2. Tidal

This data processing is carried out for 15 days because it includes one tidal cycle that is full tide and tidal Perani .Tidal data taken represents two different seasons, for the Western Season using tidal data in December, January, February and East Season using tidal data in June, July, August Based on these data it is known that the tidal patterns in the waters of Tunda Island in the West Season (DJF) and East Season (JJA) show a diurnal mixture of single leaning (diurnal) with a formal value of 2.11. This shows that the type of tides that occur in one day can consist of 2 tides or two tides, or can also be one tide and one tide. In one month the condition of one tide and one ebb in one day occurs more dominant so that the condition can be said to be a diurnal type. The data processing is followed by data from the Banten Province Department of Environment and Forestry, which states that Tunda Island has a diurnal tidal type with a formhazl value of 4.23 [19].

Tides are very influential in the distribution of debris on the coast. When the condition of the tide of debris around the waters of Tunda Island moves towards the coast and accumulates, while at low tide the debris on the coast will be carried away from the coast and transported to other places. Tunda Island which has a semi-diurnal tidal type that tends to diurnal will experience at the same time a process of accumulating debris on the coast and transporting debris from the coast in one day.

3.3. Data validation

Validation of tidal data is done using RSME calculation (error value). The primary data being compared is data from ICO Sea Level Monitoring, at Kolinamil Jakarta station. That is because of the limited tidal data available, there are only five stations in Indonesia. Kolinamil Jakarta is the closest station to Tunda Island. Therefore, tidal data at the Kolinamil Jakarta station is used as a comparison data. Based on calculations the error value of the model ranged from 0.08 to 22.2%. The West Season the error value is lower than the West Season. In the West Season, the error rate ranges from 0.08 - 11.6%. The error value in February showed the lowest rate of 0.08%, it shows that the sea level elevation from modelling has a very low error and almost shows an accurate value. Whereas in the East Season the error rate ranged from 8-22.2%. In the West Season, it is seen that there is a significant difference in error value, in July it showed an error value of 8%, while in August it showed a 22.2% value.

3.4. Current

Based on the current simulation shows the current Tunda Island dominated by the type of tidal currents alternating (reversing current) or can be referred to as rectilinear tidal current. Figure 4. Shows current patterns that occur in the West Season. Based on hydrodynamic simulations of current movement patterns during the West Season when the tidal conditions dominant currents move from north to southwest to the waters of the Banten Bay and Sunda Strait, except in February the currents move from the northwest to the southeast. The difference in the direction of the current is due to the influence of the strong West monsoon in February. So that the current movement originates from the northwest to the southeast. While at low tide the current moves from the south, namely the Banten bay to the northeast. The current velocity at high tide shows a lower value than at low tide. When the tide conditions the average current speed around Tunda Island is 0.04 - 0.28 m / s, while at low tide conditions the current speed increases with an average speed between 0.01 - 0.6 m / s. The high speed of the current at low tide due to the influence of wind conditions on Tunda Island which tends to move from the southwest. So that the wind speed also affects the velocity of low tide

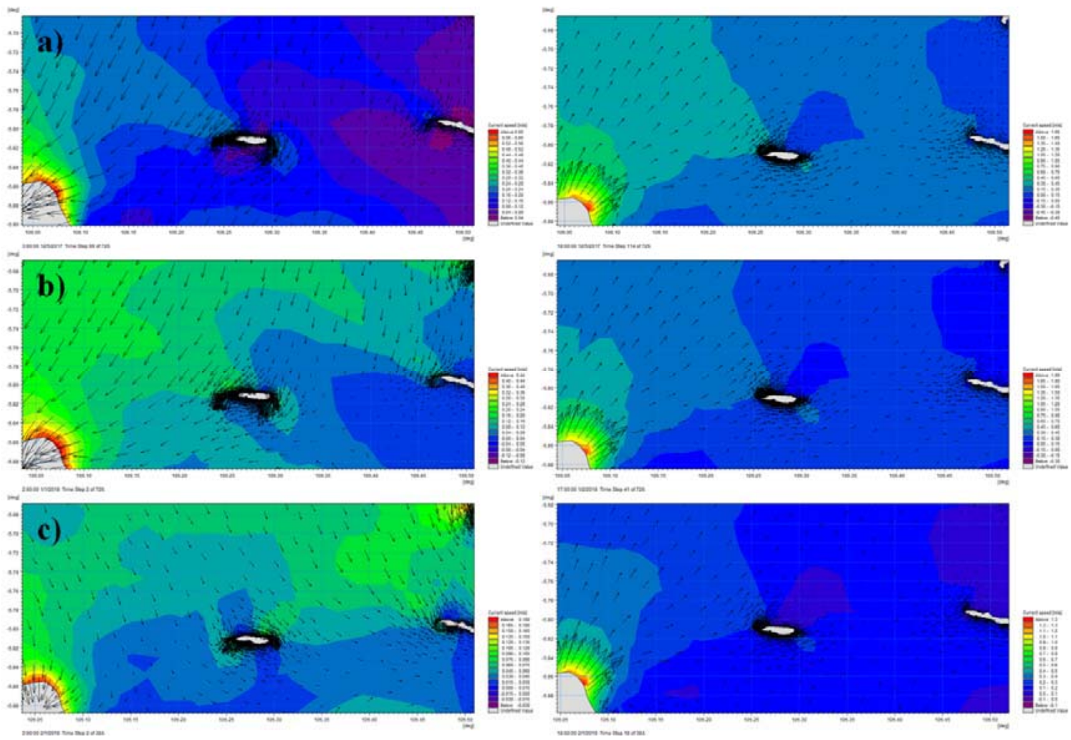

Figure 4. The current condition of ups and downs (a) December 2017 (b) January 2018 (c) February 2018.

Figure 5. Shows current patterns that occur in the East Season. Based on the simulation results the current East Season current pattern is not much different from the current West Season pattern. The direction of the current East monsoon which lasts for three months starting from June to August shows the same direction of the current which is moving from north to southwest at high tide, and moving from southwest to northeast at low tide. The current speed at high tide is also lower than at low tide. The tidal current velocity during the West Season shows a lower value, with the lowest tilapia of 0.01 m / s, but the highest speed reaches 0.3 m/s. Whereas during low tide the current speed in the East Season reaches 0.9 m / s. That is due to the influence of the East Seasonal wind which moves from south to north so that during low tide conditions the monsoon wind also influences the strength of the current movement. Current pattern conditions that do not address differences during the West and East Season due to the characteristics of Tunda Island waters that have Tidal Currents. This current will move back and forth throughout the year or is called a rectilinear current [20]. However, the influence of monsoons has little effect on the speed of alternating current that occurs.

The current pattern on the island of delay in the west season and east season has the same condition that is moving back and forth. Then these currents will experience shoreline currents after reaching the coast. When the tide will move from the north then it will split into two directions when heading to the north coast and again meet on the south coast, after that the current will move together towards the southern waters of Tunda Island, and vice versa when the receding conditions of the current moving from the south are divided into both ways and meet again in the northern part of the island. The Tunda Island current pattern is strongly influenced by the tidal system, so it is called tidal current.

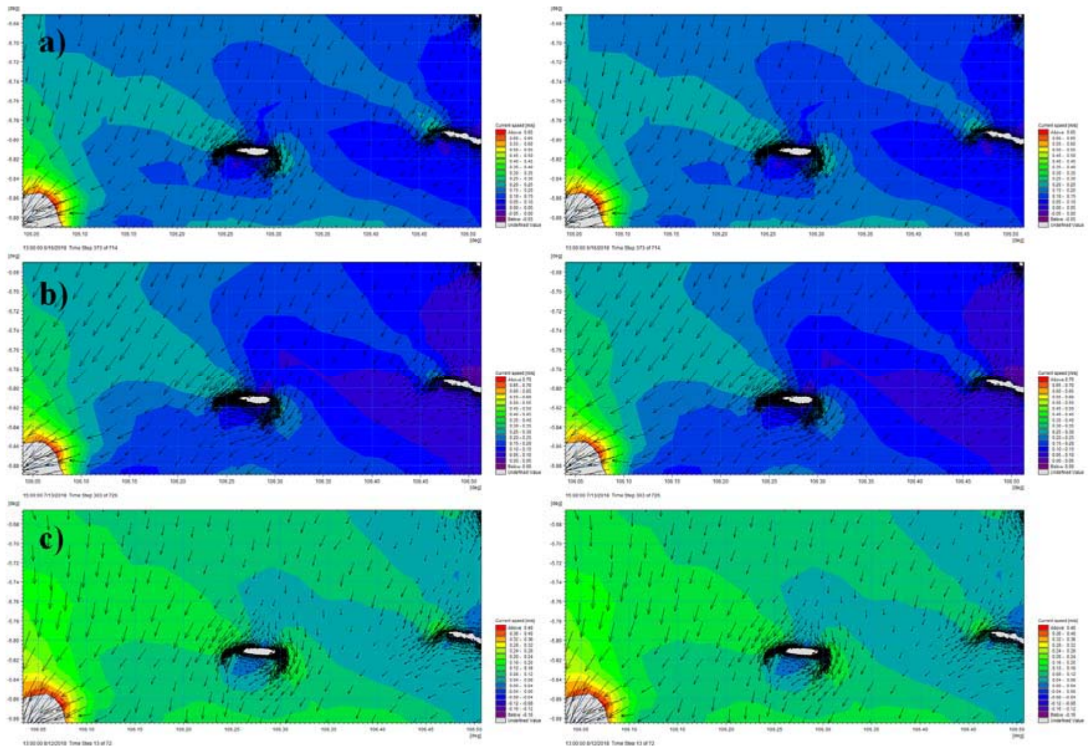

Figure 5. The current condition of ups and downs (a) June 2018 (b) July 2018 (c) August 2018.

Tidal currents are very influential in the distribution of debris on Tunda Island. Based on hydrodynamic simulations, during the West Season and East Season currents will move back and forth or tides. When the tidal and low tide conditions that move towards Tunda Island will be divided into two directions when they reach the coast of the Island, some of the currents will move east and west along the coast of Tunda Island and will then meet again and move in the same direction. Irregularities along the coast occur due to the outbreak of incoming waves and form a greater angle of 5º [21]. The current will experience a deflection when it reaches the coast, some will turn around and some will move along the coast. The current is very influential on the transport and distribution of debris on the island of Tunda. During the West monsoon and East seasons, tide conditions will move from north to south. This current will bring debris material from northern waters to Tunda Island. Then it will move along the west and east coast to the south. During the coastline process, currents will carry debris material from the north coast to the south. So there will be an increase in the amount of debris on the south coast. However, the distant location of the north coast of Pulau Tunda from human activities causes at least the amount of rubbish available so that the addition of rubbish from the north to the south coast is very low. However, this flow will bring material along the south coast to the offshore waters leading to Java

In low tide conditions during the West Season and East Season, the current will move from south to north. The current moves from Java to Tunda Island. The current will bring material from other places to the coast of the southern coast of Tunda Island, causing accumulation of all the debris carried by the current to the south coast of the island. However, when the current goes to the south coast the current will divert into two directions to the west and east. The coastline currents will carry debris material from the southern coast of the island to the south. The high level of debris in the southern part of the island is caused by the location of the beach which is directly facing large islands and settlement activities. The current will distribute debris from the south coast to the north coast. This will increase the amount of debris on the north coast. This causes the emergence of debris in the northern part of the island which does not occur human activity.

During the West Season, the tidal currents are higher due to the influence of monsoons that move from the north to the south. Whereas during the East Season the ebb flow velocity will be higher because of the influence of the wind that moves the surface currents from south to north. When the East Season, the distribution of debris from Java and Lampung Island will be faster because the debris transfer will be farther away than the West Season, it is because the transfer of debris from these islands is carried by the current during low tide.

3.5. Partical trancking

Modeling the movement of particles is done by determining the location of the Hypothetical Source. The location is determined based on the hydrodynamic condition of the waters around Tunda Island and the rubbish found. There are 4 points that are assumed to be sources of the emergence of debris on Tunda Island, namely the Muara Sungai Cidurian (SP 1) located in Bogor district. Ciujung river estuary (SP 2), Cibanten River Estuary (SP 3) and Cilegon River Estuary (SP 4) located in Serang Regency, Banten. River estuary is one of the main sources of debris originating from land to sea. That is because the flow of the river that carries materials from the land will end up at sea. This modeling is done by combining the oceanographic conditions of the West and East Seasons. This was done to find out which sources most affected the presence of debris on the coast of Tunda Island for six months.

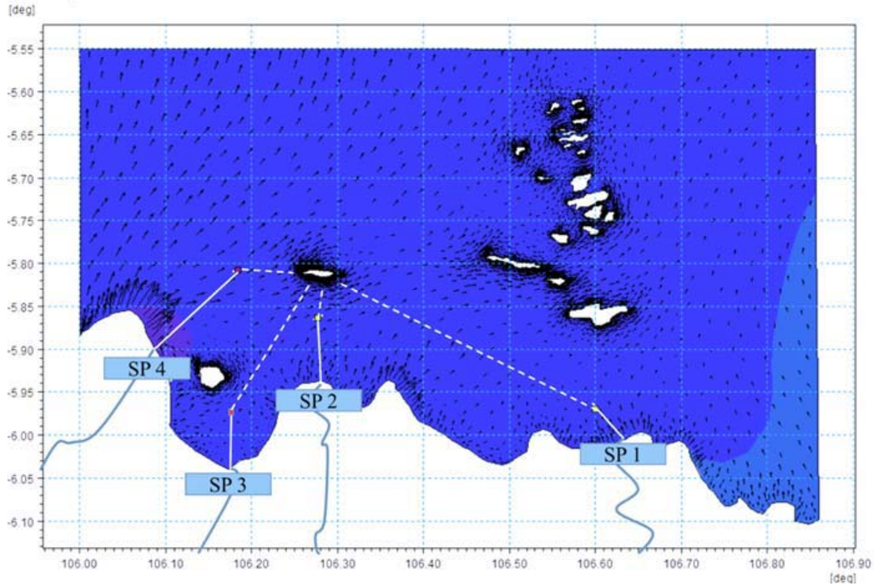

Figure 6. Pattern macro debrish movement in the west and east season.

Figure 6 shows the last position of macro debris particles for two seasons. The simulation was carried out for six months and resulted in the movement of debris from its source with different distances. the average movement of macro debris particles ranges from 4.84 to 14.3 km with the furthest displacement of 14.3 km at the Cilegon estuary. Debris moves with the flow for six months. The movement of debris is not too far away because the alternating current that occurs in the waters causes debris that has been carried away from the source to return to the starting point. Based on the remaining distance from the endpoint to Tunda Island. Then it can be analyzed the time taken by the debris to get to Tunda Island from each source.

The remaining distance from the Cidurian estuary is 37.7 km, the debris in the estuary moves almost 5 km for 6 months. So the time needed for debris to arrive in Tunda Island is around 42 months, the slow movement of debris from Muara Cidurian is due to the distance from Tunda Island and the number of small islands around these waters which causes the macro debris transportation to be blocked. As for the trash from Muara Ciujung which moves as far as 8 km in 6 months, leaving 4.17 km to get to Tunda Island. So that the remaining time needed for debris from Muara Ciujung is only about 3 months. The debris from Muara Cibanten moves as far as 5.22 km with a remaining distance of 19.4 km. Based on the analysis of the time taken for debris from Muara Cibanten to Tunda Island around 21 months. The slow movement of debris in Muara Cibanten due to alternating current and obstruction of the transfer of debris by Pulau Panjang. So that when there is an ebb current that carries debris away from Muara Cibanten, the current will be reversed quickly due to the impact of Pulau Panjang. The removal of debris from Muara Cilegon for six months is 14.3 km. The transfer of debris from Muara Cilegon is the furthest distance taken in only 6 months. This is due to the high tide and low tide speeds that occur around Cilegon waters. The high speed of the current around the waters of Cilegon is due to other currents that help in the movement of tidal currents. Based on the analysis of the remaining distance of macro debris for debris to Tunda Island is 7.29 km, and the remaining time needed for the debris to Tunda Island is only 3 months. Analysis of the remaining time taken due to the water flow patterns that do not change direction, due to alternating current patterns when ignoring the anomalous waters that will occur and cause significant changes in current patterns. Debris originating from Muujung CIujung and Cielgon are moving faster than from other sources because there is no obstacle to the current movement by small islands and the direction of the current that moves vertically towards Tunda Island. Whereas debris from Cibanten estuary is blocked by Panjang Island, Cilegon estuary is blocked by Tarahan Island.

The average pattern of debris movement that occurs in the West Season and East Season experiences the same pattern of moving back and forth, ie approaching and away from the source. This is also needed by research on microplastic movements in the Java Sea precisely in the waters of Biawak Island, the study says that microplastic movements from the source move back and forth due to the Java Sea currents affected by tidal currents [22].

3.6. Comparison of macro debris between season and west season

Identify the macro coastal debris Tunda Island refers to the International Clean Up Data Form of Ocean Concervacy modified. Such modifications and additions in the form of simplification kind of debris categories On the form there are seven categories of debris are Most Often Found, Arrest, Packaging Materials, Other Trash, Personal Hygiene, and Tiny Trash Less Than 2,5 mm and Wood Base Materials (additional categories). Each of these categories is subdivided into several types of debris. Simplification of form data were done on the type of debris category "Most Likely to Finds Items".

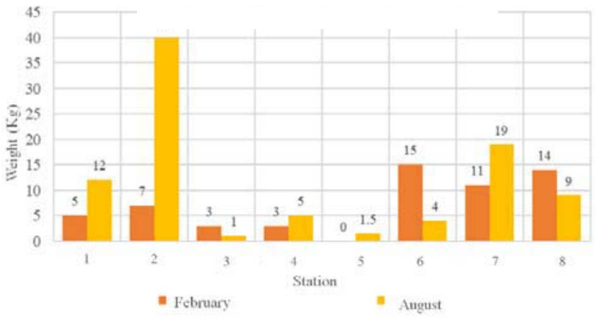

Figure 7. Comparison of Debris Based on Weight.

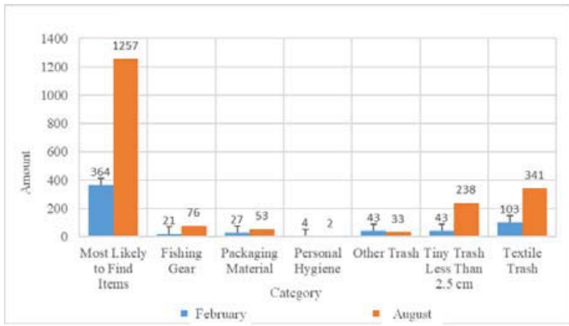

Figure 8. Comparison of Debris By Category.

Figure 7 Shows the weight of debris in February and August. The highest weight difference was seen at stations 1, 2, 7. In February, the weight of debris at station 1 was only 7 kg, while in August it reached 40 kg. Based on the analysis in the field, the factors that influence the increasing amount of debris at Station 1 are due to the increased activity of fishing ship construction and repair. So it is found rubbish from the ship like a tire. In August, there were 4 rubbish tires found in intact condition. Besides that, there is whole closet debris. Both types of rubbish greatly affected the increase in the weight of debris in August because the basic material of the rubbish is made of rubber and cement which has a heavier period than plastic and glass.

The weight of debris at Station 2 has a difference of 7 kg, in February it was 5 kg, while in August it was 12 kg. The increase in debris is analyzed because of the discovery of the "Taro" snack food plastic packaging debris. The photo of the trash can be seen in Appendix 5. "Taro" debris is found in the form of large plastic sheets that have not been cut according to the size of the food packaging in the market. When viewed from the form of the debris it is thought to be a wrapper that fails to be produced so that it is discarded. The analysis of the source of debris is due to the location of the nearest "Taro" factory is the city of Bogor. Based on the analysis it is assumed that this debris originates from the Cidurian River Estuary. Cidurian River is one of the rivers that empty into the Java Sea. This river flows through several major cities before finally empties into the Java Sea including Pandeglang Regency, Lebak Regency, Serang Regency, Serang City, Cilegon City, parts of Tangerang Regency and part of Bogor Regency. So that the possibility of wrapping debris is carried by the Cidurian river and empties into the Java Sea. Then the debris is carried by the current flowing to Tunda Island. The rubbish was found at station 2. The type of beach at station 2 that is open without any obstruction from breakwater, jetty or mangrove causes the debris can accumulate there. The location of Station 2 in the southern part of Tunda Island and directly facing the island of Java causes debris originating from Java Island to accumulate more quickly at station 2.

The increase in debris weight at Station 4 was analyzed because of the high discovery of 55 glass bottles. Glass is a packaging material that has a greater weight than plastic. So the effect of glass bottle sap on the increase in the weight of August debris at station 4 is high. The beach type of station 4 is an open beach, causing sea trash that is carried by currents and tides to experience a high accumulation process around the coast.

Based on a comparison graph of the weight of rubbish every season 1,2,3,4 stations in the southern part of Tunda Island tend to have a higher weight than the 5,6,7,8 station in the northern part of the island. This is because the locations of stations 1 to 4 are near the main settlement and face to face with Java and Sumatra. So that high debris production will occur every day. Also, the type of open coastline causes a high accumulation of coastal debris at the four stations. That is because debris that is carried by currents from other places will be more easily carried by tides and accumulates on the coast. While the location of the station 5,6,7,8 which is in the northern part of the island, is located far from residential areas and large islands. So that the process of distributing debris from other places that accumulate on the coast will be even lower.

Figure 8 shows the increase in debris in almost all categories. There is an increase in debris in the category of Most Often Found, Arrest, Wrapping Material, Small Pieces Trash, and Tree Base Materials. The increase of debris in the category of Most Often Found and Packaging Material is greatly influenced by the type of plastic packaging debris. Based on the identification, 253 were found in February and 786 in August in the Most Frequently Found category. Whereas in the Wrapping Material category, 27 were found in February and 36 in August. The increase in the amount of plastic debris is due to the higher consumption of plastic packaging every year in Indonesia. In 2017 the amount of debris was 7,175,779 kg, then there was an increase in debris in 2018 of 7,262,968 kg and again increased in 2019 of 7,351,315 kg [23].

In the category of Fishing Gear which is debris from fishing activities. This category of debris also experienced a significant increase. In February only 21 rubbish was found, but in August 76 rubbish was found. The increase in debris is due to an increase in fishing trash activities during March-August around the waters of Banten. This was stated by several studies. In March-August is the peak of white anchovy fishing trash (Grade A) and yellowish anchovy fish (Grade B) and in June the fishing crab in the Banten waters[24]. In the west season, especially from December to February, Debris Catching pelagic in Pandeglang waters, Banten does not take place [25].

Small Piece Trash has increased from 43 units to 238 pieces of debris. This rubbish is a type of small pieces of foam, glass, and plastic. This increase in debris is greatly influenced by the high invention of foam type rubbish. This piece of rubbish foam comes from "pop noodle" rubbish which is based on styrofoam and a place to store fish, afloat for Bubu (fishing gear). As previously said that in March-August is the peak of the Debris Catching season in Banten waters with traps and other fishing gear. So that the presence of Bubu that floats in the waters will be more and more, and cause the presence of styrofoam in the waters increases. As a result of the existence of styrofoam, currents will be degraded into small pieces.

The increase in debris of tree base materials is due to the increasing number of sandal and shoe debris discoveries, and in August several blankets and bolsters were discovered. The rubbish was not found before in February. In February, only one type of debris was found, sandals and shoes. But in August found blanket trash, bolsters, bags, and sacks in conditions that are still intact with little damage.

In the category of Personal Hygiene debris found special debris that is the type of drugs found as many as 3 pieces. The debris consists of medicine bottles and infusions. This type of debris is a dangerous hospital debris. Infusion-shaped debris that was found turned out to be a urine tube that is commonly used by patients with kidney disease or diseases that make a person difficult to use the urinary tract. This rubbish was analyzed carried by the ocean currents from the big island. That is because in Tunda Island there are no hospitals or health centers that can produce this type of debris. Based on the analysis of infusion rubbish and the drug coming from a large hospital on the island of Java, it is because the big island that is closest to Tunda Island is Java. So that the influence of debris transport from Java will be greater than other islands. Besides, this infusion and drug debris was found at station 2 which is located in the southern part of Tunda Island, which is directly facing the island of Java.

3.7. Distribution analysis of marine debris

Seasonal differences can affect the distribution of waste on Tunda Island due to differences in oceanographic conditions which are a factor of the distribution of waste in a place. Oceanographic factors that influence the distribution of waste include wind, currents, and tides. Currents can carry waste from other places [26]. While the wind and tides affect the movement and speed of the current.

Based on the analysis of oceanographic conditions and the facts in the spatial distribution of garbage on Tunda Island, it is very highly influenced by tidal and coastal shore currents. But the season also influences the speed of the current, but it is not too significant. The amount of rubbish in the southern part is influenced by settlement rubbish and garbage sent from Java. While the existence of garbage in the north can be caused by two factors of shipment of waste from the northernmost island and the results of the transport of waste from the southern part of the island. However, the most dominant source is the transport of garbage from the southern coast due to coastal drift. That is because the distance of Tunda Island with other islands in the north is quite far. So it takes quite a long time for garbage to arrive at Tunda Island.

4. Conclusion

Based on the research, it can be concluded that Season influences the quantity of waste on Tunda Island. The amount of waste in the East Season is higher than the West Season with an average increase in the total weight of 9 kg of waste. That is because during the east season there are a lot of fishing and tourist activities. A low tide that carries waste to the coast of Tunda Island has a higher speed during the East Season. Besides the wind speed that will generate surface currents in the east monsoon is higher than the west monsoon. It affects the addition of the amount of waste in the category most often found, catching, wrapping material, small pieces of waste and tree base material. Season influences the speed of alternating current as a factor in the distribution of waste on Tunda Island. Based on the results of the modeling of potential sources that affect the existence of waste on Tunda Island is the River Ciujung.

5. Suggestion

We need to do a simulation with a longer time in order to find out how long it takes the debris to get to the Tunda Island. Besides the need for the additional stimulation of several points which are assumed to be hypothetical *source including* in the thousand islands and estuaries Lampung north.

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