JURNAL SEGARA
http://ejournal-balitbang.kkp.go.id/index.php/segara

ISSN : 1907-0659
e-ISSN : 2461-1166
Accreditation Number: 766/AU3/P2MI-LIPI/10/2016

CHARACTERISTICS OF MARINE LITTERS IN THE WEST COAST OF BALI

Semeidi Husrin[1,2)], Ulung Jantama Wisha[2)], Rahmadi Prasetyo[3)] Aprizon Putra[2)] & Adli Attamimi[4)]

[1)]Marine Research Centre, Ministry of Marine Affairs and Fisheries, Republic of Indonesia, Jakarta
[2)]Research Institute for Coastal Resource and Vulnerability, Ministry of Marine Affairs and Fisheries, Republic of Indonesia, Padang
[3)]Biology Conservation Program, Dhyana Pura University, Bali
[4)]Faculty of Fisheries and Marine Science, Padjadjaran University Bandung

Received: 17 May 2017; Revised: 19 May 2017; Accepted: 28 July 2017

ABSTRACT

Kuta beach in Bali is a world-famous tourist destination has been suffering from marine litters (or debris) disaster almost every year. Mitigation efforts have been carried out by the local government started from educating the people as well as continuing mass cleaning campaigns for the stranded litters in the beach. The research has an objective to understand the physical processes of marine debris characteristics in Kuta such as its propagation and distribution along the coastline and in the water columns during the two different seasons (West Monsoon and Transitional seasons). A hydrodynamic model was developed to investigate the transport of marine litters from their sources by considering the tide-driven surface currents and wind. Field surveys were also conducted to assess marine litter's characteristics in the surface and in the sea beds for both plastic and wood types of litters. Hydrodynamic simulation shows that the surface current ranging from 0.05 – 1.75 m/s is capable of transporting marine surface debris from Bali Straits and other sources in the South of Bali to Kuta during West Monsoon season. The collected litters during the West Monsoon season were four times larger in quantity. The concentration of litters in the seabed and in the water column is larger near to the coastline than further offshore. In the meantime, during Transitional season, Kuta was completely free from marine litters. Results from surveys also showed that the most effective measures for marine litters in Kuta is self-awareness of the people to keep the environment clean.

Keywords: marine litters, pollution, hydrodynamics, Kuta, Bali.

INTRODUCTION

Global concerns towards the abundance of litters in marine environment have increased in the last decades causing not only environmental problems but also economic loss (Wang *et al*., 2016). Its worldwide distribution and the massive volumes of marine litters were reported may reach 150 million tonnes and the numbers will keep increasing because it was estimated that 4.6-12.7 million tonnes of litters were dumped into the ocean every year (Jambeck *et al*., 2015). Over the years, the type of litters has been dominated by plastics and other non-degradable materials originated from all kind of human activities such as littering in the tourism area, shipping and fishing industries, dumping in the oceans, untreated rivers/floodwaters, etc (Werner *et al*., 2016). These conditions harm the live in the oceans as reported in the USA that more than 115 marine species were found affected by the plastic litters (NOAA-MDP, 2014), while it is estimated that every year marine animals may have been debilitated, mutilated and killed by plastics worldwide (Butterworth *et al*., 2016). Recent publications showed that micro-plastics may also have affected the health of marine lives (e.g. fish, shells, birds) and the consumption of them definitely will harm humans as well (GESAMP, 2016).

Large population in coastal area and its geographic locations between the Indian and the Pacific oceans has made the Indonesian waters reported as one of the polluted waters by marine litters (OSPAR, 2009). Strong wind and current circulations play significant role on the transportation and distribution of marine litters in Indonesian waters (Lebreton *et al*., 2012). The transportation and

Corresponding author:
Jl. Pasir Putih I Ancol Timur, Jakarta Utara 14430. Email: s.husrin@kkp.go.id

accumulation of marine litters in Indonesian waters can be easily observed in many coastal area of large cities such as the North of Java and East of Sumatera. Bali, a small island with large population recently has caught both national and international attention due to huge amount accumulation of marine litters that were frequently accumulated in the touristic area of the island (Time, 2011).

Pantai Kuta (Kuta Beach of Bali) is one of world tourist destinations for the beach, cultures and water sports in Bali. However, during Northwest Monsoon Season (or simply west monsoon season), Kuta Beach has turned to be a "dumping area" of marine litters and lasted for months. In the past, the typical marine litters were dominated by woods or other organic-type litters which can be re-used by the villagers of Kuta (Yunanto *et al*., 2014). In recent times, the deposited marine litters were dominated by plastic-based materials disturbing the tourism industry and damaging the ecosystem. Efforts have been carried by the authority to clean up the beach during the litter's season by establishing a Fast-Reaction Cleaning Service Unit (FRCSU) consisting of professional cleaning teams, tourism-industry players and the locals (villagers). The locals claim that the marine litters stranded in Kuta are originally from East Java based on the physical appearance of the litters found in the beach. However, since the Island of Bali has been experiencing major development in the last decades and large rivers are also found in the Western part of Bali, the litters may also from the island itself. Efforts have been made to understand the transportation of marine litters by means of numerical simulation (Yosafat, 2012). However, the model only explained the propagation of marine litters in the surface during West Monsoon season. So far, there is no any information on the distribution of marine litters in the water columns, seabed and its distribution in cross-shore direction. Thus, scientific research is needed in order to explain the origin, the propagation and the deposition of the litters during the two seasons along the coastline and in cross-shore directions. Therefore, the current paper has an objective to explain the characteristics and dynamics of marine litters originated from Western area of Bali Island (Bali Strait) until reaching the Kuta Beach. Based on the analyses, recommendations for the alternative of marine litter mitigation in the future are proposed.

METHODOLOGY

Field research was done in Kuta beach in the Bali Island (Fig. 1). General research methodology is depicted in the flowchart as shown in Fig. 2. First, literature searching was conducted to find information about marine litter abundance, propagation, occurrences, monitoring techniques, numerical simulations, and the impact of marine litters to the environment particularly for the cases in Kuta beach of Bali including the collection of any useful secondary data. The collected information from the literature

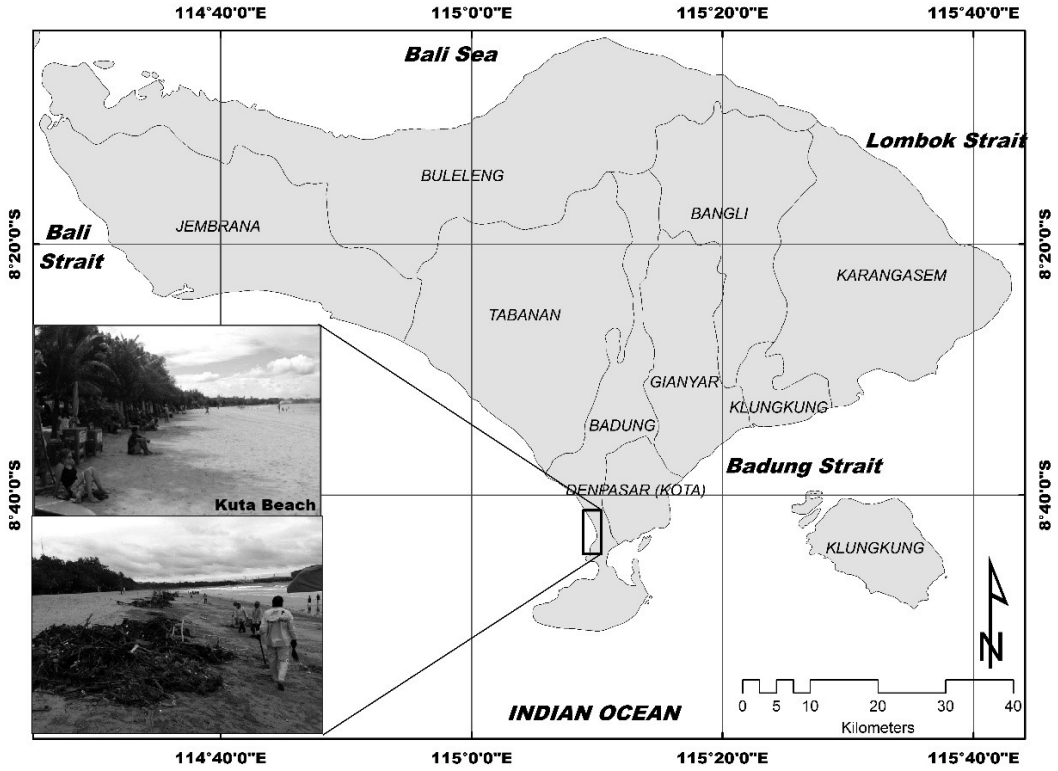

Figure 1. Location of Kuta beach in the Island of Bali and Marine litters found in the beach during Northwest Monsoon season.

studies were summarized and discussed with the experts and the locals in order to specify the objective of the research and the methodology. Based on the consultation and discussions and by considering the resources available, the objective and the research methodology were specified. Field surveys were done in March, April, December 2015 and February 2016 in order to cover both west and east monsoon seasons. In advance, numerical simulations for the hydrodynamic and particle propagations were carried out in the area using Mike 21, Hydrodynamics and Particle Tracking Modules. The bathymetry from the Indonesian Navy (Dishidros AL), the tides from Pengambengan Tide Station, and wind data from the Denpasar Airport were used for the model inputs.

Based on the literature studies and the preliminary numerical model, data of the beach, seabed (benthic) and floating litters and water quality in Kuta waters were collected. Beach litters were collected, classified and measured based on the guidance of OSPAR (2010) in March 12th, 2017 or during the West Monsoon Season 2014/15. In April 12th – 15th, 2015 or at the Transitional Season and on Feb 1st – 3rd, 2016, seabed litters were also collected.

Sea bed litters were collected by professional divers at 6 (six) different locations offshore Kuta beach by taking a transect line of 100 m long for each. A rope was used to guide the divers while collecting the litters in seabed. Both ends of the rope were tighten on the anchor connected to the boats. The locations for the collection of seabed litters based on the information from the local fishermen who used to fish in the area. They mentioned that during west monsoon season, their fishing nets often trapped more plastics and other litters than fish. During this period or at the end of west monsoon season, it was necessary to check whether the litters remained in the seabed or carried by the changing currents.

The impact of marine litters to the quality of waters by measuring the water quality parameters (pH, temperatures, DO, salinity, turbidity, conductivity, and depth) was also investigated. Beside, an interview survey including about 100 people was done to look at the social aspects of human behaviours towards littering in the area.

Floating litters were investigated on December, 28th – 31st, 2015 (or during West Monsoon Season 2015/16) by aligning 3 (three) boats in perpendicular direction to the shoreline in the North of Kuta started from 500 m from the shoreline and other 500 m of equal distance for each boat in offshore direction. The collection of litters were carried out using the fishermen nets (a cone-shaped fishing net with 1 m diameter at the opening, mesh size 2 mm and attached to a 1 meter long stick) in early morning around 6 o'clock Central Indonesia Time (or local time) for a duration of 1 (one) hour. During this period, observations to the 5 (five) river mouths in the South and West of Bali and 1 river mouth in the East Java (a province, West of Bali) were carried out for the confirmation of litter's origins that

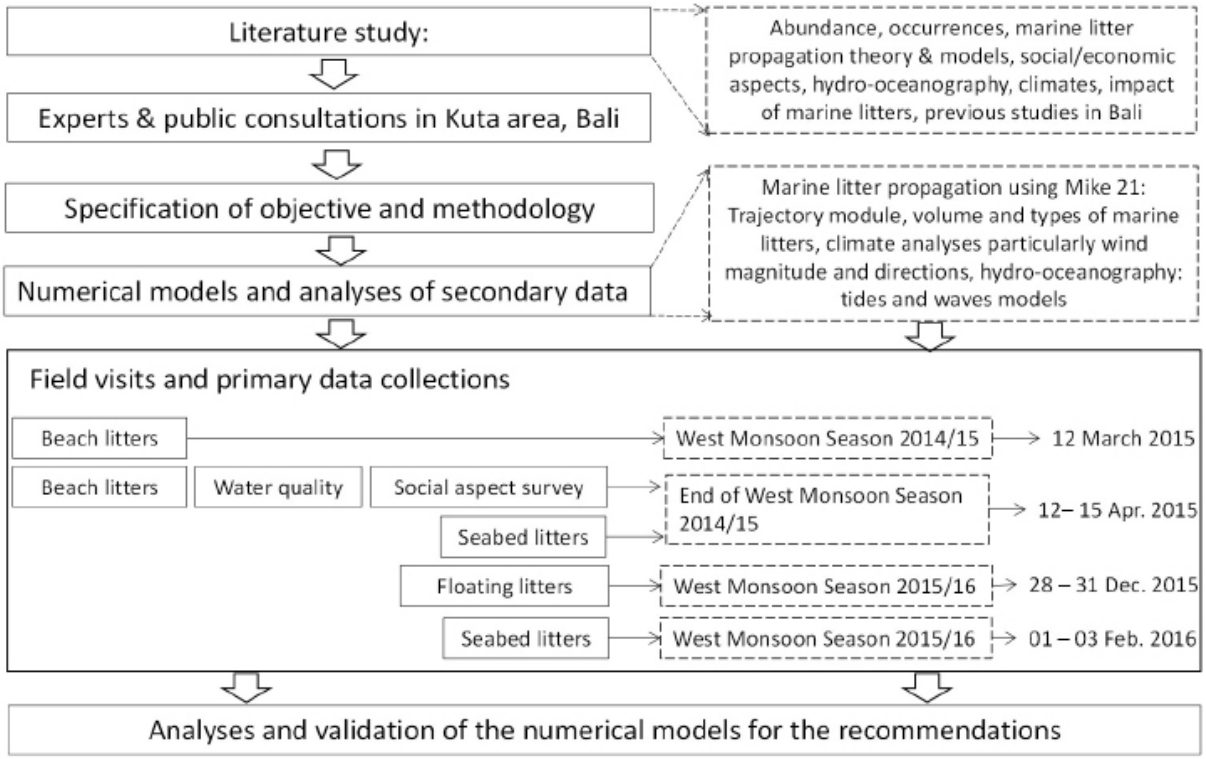

Figure 2. Flow chart of general research methodology.

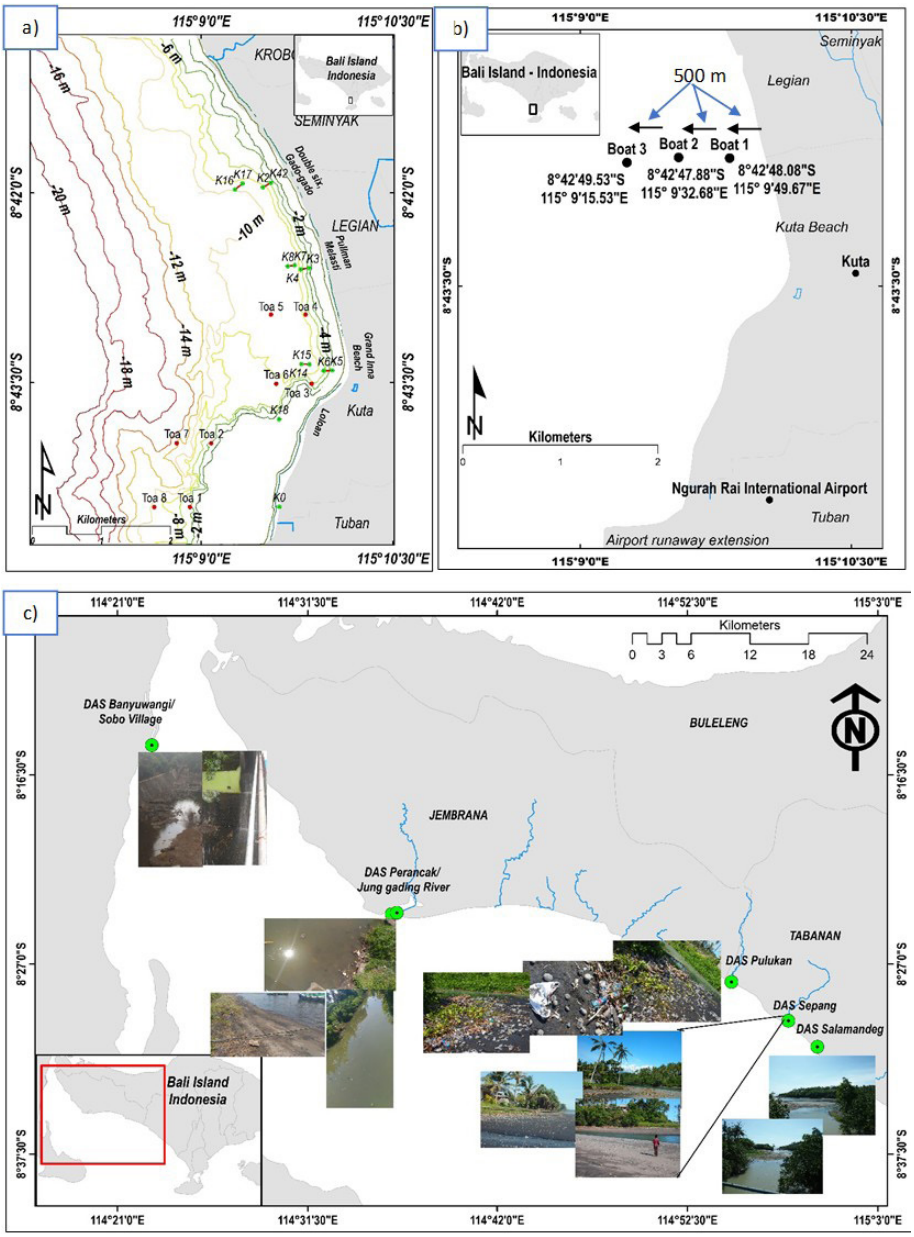

Figure 3. a) the surveys locations for beach litters, seabed litters ("K" points and straight red lines) and water quality ("Toa"), b) the survey locations for floating litters and c) the observation of litters in the 6 (six) river mouths (marked as DAS).

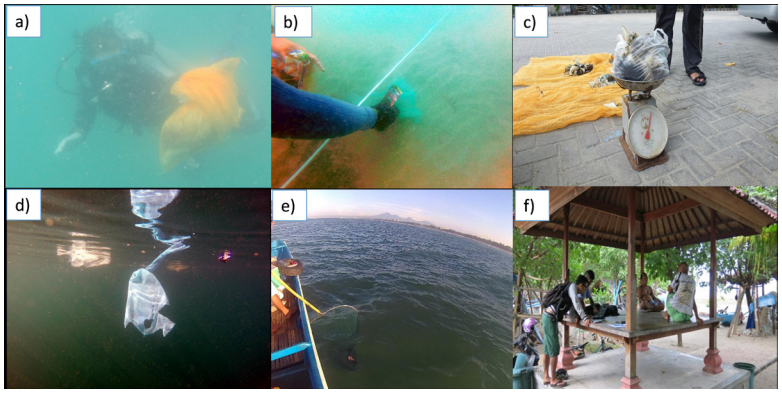

Figure 4. a) A diver collecting litters in the seabed, b) The condition of the seabed c) Weighing of collected litters d) Floating plastics litters, e) a cone-shaped fishing net to trap floating litters offshore, and f) Interview of the locals.

may be released from those rivers (mainland). All locations of the field surveys as described above and the processes of data collections are shown in Fig. 3 and 4.

RESULTS AND DISCUSSION

Numerical simulation of marine litters

The hydrodynamic simulation was carried out for 15 days from December 4th – 18th, 2014 or during west monsoon season. Whereas, the trajectory model or the propagation of litters uses 6 (six) sources as shown in Fig. 5a (see also Fig. 3c). The bathymetry of the model domain is shown in Fig. 5b and the validation of the hydrodynamic model using tide's data (RMSE ~4 %) is shown in Fig.5c. Strong currents were identified entering the Bali Strait in southward direction. Strong wind (3.8 m/s in average) from the West towards East made a concentration of current along the coastline of west and south Bali. Hydrodynamic simulation shows that the surface current ranging from 0.05 – 1.75 m/s

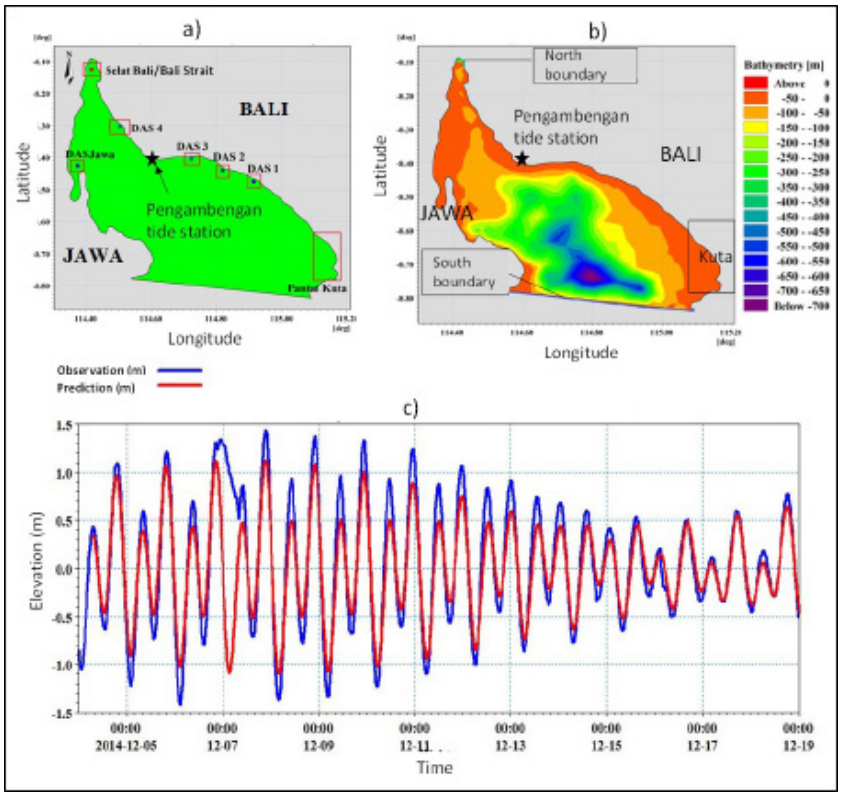

Figure 5. a) The source of litters, b) the bathymetry used in the simulation and c) the validation of tides for the model and the observation in Pengambengan.

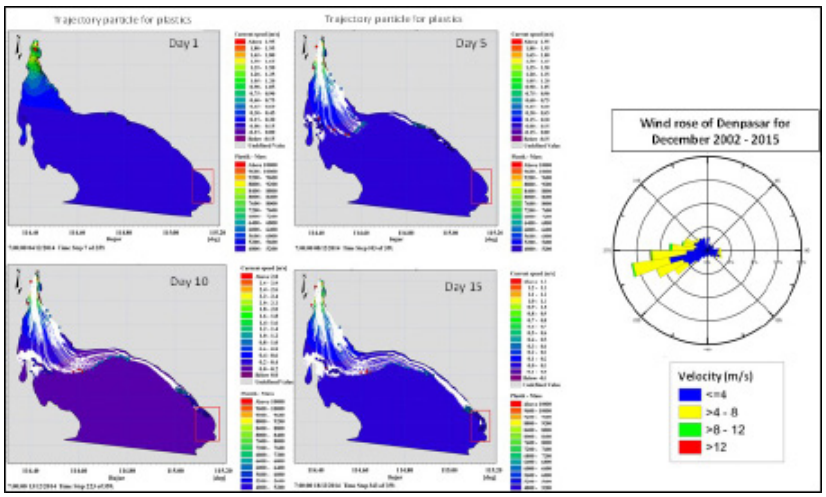

Figure 6. The numerical model of plastic litter propagation for 15 days.

is capable of transporting marine surface litters from Bali Straits and other sources in the South of Bali to Kuta during West-Season. According to the data from the office of waste and park management (or Dinas Kebersihan dan Pertamanan), Kuta area resulted 8 – 10 tonnes of litters per day during the west monsoon season. Based on this information, it is assumed that the sources of litters (Fig. 5a) release 1 kg of litter per second or 95,000 kg during the 15-day simulation or around 6,300 kg of litters will be deposited in Kuta. The simulation was conducted for both plastics and wood materials. In this paper, only plastics simulation was displayed. For more detailed information on the simulation of marine litters using numerical model Mike 21 for different scenario and conditions can be found in Attamimi (2015).

Fig. 6 shows the simulation of marine litters from the sources towards Kuta. The influence of wind and the geometry of the area can be seen from the propagation of marine litter on day 10 where large amount of floating plastics diverted to the coastal area of Bali and finally deposited in Kuta beach.

Beach litter survey

Beach litters in Kuta during west monsoon season were extensively surveyed and identified by Yosafat (2012). In the current research, the survey of beach litters was only dedicated for qualitative indications. It means that the observation is used to convince the previous results as described by Yosafat (2012). Based on our observation on March 12th 2015, the litters deposited in the beach of Kuta was immense as can be seen in Fig. 7. We had difficulties to take sample of litters because the amount of litters needed machineries to handle and the Fast-Reaction Cleaning Service Unit (FRCSU) had been cleaning – up the beach since the very early morning. This problem was also identified by Ryan *et al*., (2009) in which monitoring litter stranded on the beach is critical for discussion due to so many aspect should be considered for obtaining more reliable data. We returned on April 12th 2015 or at the Transitional Season, we still could observe litters transported and deposited to the beach. A survey was then conducted by collecting litters on the beach (100 m long at three locations, Fig 3a) after the mass cleaning activities or around 9 AM in the morning and we found 26.6 % of plastics and 73.4 % are wood/organic materials. Details on the survey and identification of beach litters can be found in Attamimi *et al*., (2015).

Seabed litter survey

Seabed litters (also known as benthic litters) were collected on April 12th -15th, 2015 (transitional season) and on Feb 9th, 2016 (West Monsoon Season). There are 6 transects (each 100 m long) perpendicular to “Double Six”, “Pullman Hotel” and “Grand Inna Beach Hotel” (Fig. 3a). Only plastics materials were collected from the seabed. The collected litters from the seabed were not as much as reported by the fishermen. The collected litters from the seabed are shown in Table 1. The collected litters during West Monsoon Season are more than four times in quantity and in weight (Table 1a and 1b).

Floating litter survey

During the west monsoon season 2015/16 or on December 28th – 31st, 2015, floating marine litters were collected using three boat offshore of Kuta with 500 m distance interval. During 1 hour of measurement the collected litters are shown in Table 2 and Fig. 8. It shows that marine litters are more present near the coastline (station 1 or 500 m from the beach) compared to the locations farther (Stations 2 and 3).

Water Quality

Water quality parameters were measured during

Figure 7. Woods/organic materials dominated the litters on the beach.

Table 1a. Seabed litters on April 15th, 2015 (Transitional Season)

No	Name of the area	Location points P1	Lat/long	P2	Lat/long	Environment sea condition	Tides	Code	Litters identification Description	Amount	Weight (Kg)
1	Central Legian	K42	08^0.41.11 115^0.09.5	K2	08^0.41.95 115^0.09.4	Calm/ Cloudy	ebb	R15	Plastics	5	0.05
2	South Legian	K3	08^0.42.59 115^0.09.8	K4	080.42.60 115^0.09.7	Calm/ sunny	ebb	R15 R18	Plastics Sanitation	10 1	0.15 0.05
3	Kuta Beach	K5	08^0.43.40 115^0.10.0	K6	08^0.43.40 115^0.09.9	calm/ sunny	ebb	R15 R8	Plastics Rope	30 4	0.2 0.05
4	South Legian	K7	08^0.42.56 115^0.09.7	K8	08^0.42.57 115^0.09.6	Sunny	flood	R15 R7	Plastics Rope	47 7	0.45 0.25
5	Central Legian	K14	08^0.43.32 115^0.09.9	K15	08^0.43.35 115^0.09.7	Calm	flood			0	0
6	Central Legian	K16	08^0.40.97 115^0.09.2	K17	08^0.41.92 115^0.09.3	Calm	flood			0	0
		Total								104	1.2

Table 1b. Seabed litters on Feb 9th, 2016 (West Monsoon Season)

No	Name of the area	Location points P1	Lat/long	P2	Lat/long	Environment sea condition	Tides	Code	Litters identification Description	Amount	Weight (Kg)
1	Central Legian	K42	08^0.41.119" 115^0.09.546"	K2	08^0.41.954" 115^0.09.45"	Calm/ Cloudy	ebb	R15	Plastics	5	0.05
2	South Legian	K3	08^0.42.590" 115^0.09.845"	K4	080.42.60" 115^0.09.78"	Calm/ sunny	ebb	R15 R18	Plastics Sanitation	10 1	0.15 0.05
3	Kuta Beach	K5	08^0.43.404" 115^0.10.026"	K6	08^0.43.40" 115^0.09.96"	calm/ sunny	ebb	R15 R8	Plastics Rope	30 4	0.2 0.05
4	South Legian	K7	08^0.42.569" 115^0.09.733"	K8	08^0.42.575" 115^0.09.678"	Sunny	flood	R15 R7	Plastics Rope	47 7	0.45 0.25
5	Central Legian	K14	08^0.43.326" 115^0.09.906"	K15	08^0.43.354" 115^0.09.787"	Calm	flood			0	0
6	Central Legian	K16	08^0.40.973" 115^0.09.246"	K17	08^0.41.926" 115^0.09.324"	Calm	flood			0	0
		Total								448	4.82

the Transitional Season 2014/15 or at April 15th, 2015. As shown in Table 3, generally the water quality parameters indicate within the range of the standard (Ministry of Environment Decree No. 51/2004) except for few cases of turbidity where some values exceed the standard ones. More detailed discussion on this topic can be found in Putra & Husrin (2016). The relation of the water quality and the characteristics of marine litters in Kuta and the surrounding area are discussed in the analyses section of this paper.

Observation of the river mouths

So far, there is no any information on the conditions of river mouths along the coastline of Bali. The claim from many parties (particularly in Kuta) that the stranded litters in Kuta are from Java are questionable because there are no valid evidence up to now. Javanese waste products found in Kuta beach may have already used in Bali because most manufacturing products used in Bali are "imported" from Java. Table 4 shows the characteristics of the river mouth based on our observation in December 2015. It is likely that the rivers in Bali might contribute to the transported litters along the coastline of Bali during west monsoon seasons.

Social aspect survey

The data from this survey are valuable for the

Table 2. The results of collecting floating litters

Station	Distance from the beach (km)	Weight organic of litter (kg)	Weight of Inorganic litter (kg)	Total weight of litters (kg)
1	0.5	0.00005	2.5	2.50005
2	1	0.00001	0.5	0.50001
3	1.5	0	0.19	0.19

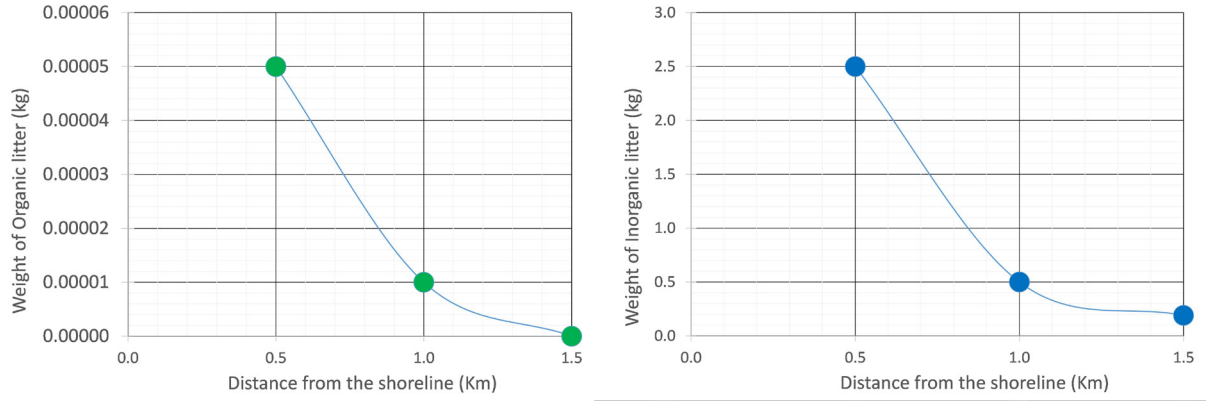

Figure 8. Distribution of floating litters (organic and inorganic litters) for each station (see Table 2).

analyses of general litter characteristics stranded in the beach of Kuta. Initially there were 15 questions but reduced to 10 questions following the consultation with the locals. The 10 questions are:

1. Are you Bali resident?
2. Are you tourists?
3. Have you seen large amount of litters in the beach?
4. Do you think the litters are from Kuta/Bali?
5. Do you think the measures to clean up the beach already done well?
6. Do you believe that the litters can be handled?
7. Do you think the tourists has responsibility for the litters?
8. Do you think the people already aware of the importance of cleanliness?
9. Do you think the government has done

Table 3. Water quality parameters (Husrin & Putra, 2016)

Parameters		Range	Averaged	Tourism Standard[1)]	Marine life Standard[1)]
Chemicals	pH	8.4 – 8.5	8.5	7 - 8.5	7 - 8.5
	DO (mg/l)	6.8 - 7.3	7.1	>5	>5
	Salinitas (‰)				
	Coral				28-30
	Mangrove	32.8 - 33.9	33.3	natural	28-32
	Sea grass				33-34
	Spec. gravity	19.8 - 20.6	20.6		
Physical	Temp (˚C)				
	Coral				28-30
	Mangrove	28.7 - 29.3	29.1	natural	28-32
	Sea grass				28-30
	Turbidity (ntu)	0.6 - 18.7	5.8	5	< 5
	Conductivity	4.8 - 5.1	4.9		

[1)] Ministry of Environment, Decree No. 51/2004

Table 4. Observation of the river mouth (see Fig.3c for the map)

No.	River mouth locations (latitude, longitude)	Description of observations1
1	Salemandeg (114.994, -8.527777)	Sediments has formed a delta, dominated by wood litters, small amount plastic litters at river body, piles of all kinds of litters at both side of the river bank
2	Sepang (114.9672170, -8.5045040)	Dominated by plastic and woods at the river bank, the sediment contains iron, near the hills/mountain, tourism area.
3	Pulukan (114.7893666, -8.4117426)	Dominated by plastic litters at the river banks, small river discharges, few wood litters observed
4	Perancak (114.6021310, -8.4029800)	The largest river mouth at Perancak, few litters observed, wood litters observed
5	Jung Gading (114.6068900, -8.4018430)	Large amount of plastic litters at the river body, trapped due to tides
6	Banyuwangi/Desa Sobo (114.3817832, -8.2472407)	Almost dry river, dominated by stones, few litters observed.

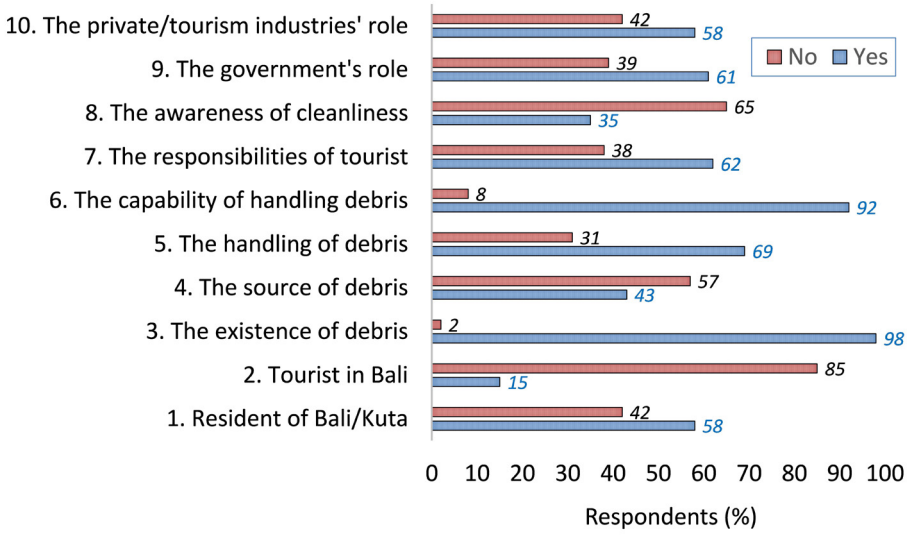

Figure 9. Survey results for the social aspects.

something proper for the handling of litters?

10. Do you think the privates also have done something for the handling of the litters?

Out of a hundred respondents, about 58% are Balinese or people who reside in Bali and 85% are not tourists. There are about 98% of the respondents have seen the huge amount of litters in the beach. Most of respondent (57%) still believed that the litters are not from Bali. Most people were satisfied with the handling of the litters in the beach (92%) and this is also related with the government and the private roles account 61% and 58% respectively in handling the litters in the beach. Many people (62%) saw that the tourist behave better for the cleanliness and this is contrary to the conditions that many locals are still not having full awareness on the importance of cleanliness (65%).

Analysis

In the past, the Balinese in Kuta used the stranded materials for many purposes due to the fact that at the time the marine litters are mostly organic debris such as timbers, bamboos, branches, and leaves (Yunanto *et al*., 2014). The increase of the use of plastics worldwide gradually change the characteristics of stranded litters

in Kuta beach. This is also one of the main reasons that until now Balinese still believe that those litters/ debris are originated from Java Island (The most populous island in Indonesia) in the West of Bali. The hydrodynamic simulation showed that the current from the north (Bali Strait) towards the south experienced circulations at certain time and locations and then move along the shore towards the south (Kuta Area). During ebb, the northward currents were diverted back to the south because the existence of a circulation before the mouth of the Bali Strait. This condition led to the accumulation of energy (strong currents) towards the south and capable of carrying litter either originated from the Bali Strait or from other sources in Bali's coastlines. The existence of several circulations in the hydrodynamic simulation is in agreement with previous works (Yosafat, 2012).

The propagation of litters mostly follows the characteristics of the currents. Litters entering the Bali Strait (Day 1), directly were carried by currents in Southward directions (with speed 0.5 – 1.75 m/s) until reach the Peninsula of Sembulungan in East Java and Perancak waters in Bali on day 4 and day 5 (Fig 6). Since the beginning, litters from other sources along the coastline of Bali were directly transported to the south following the direction of the longshore current with speed 0.25 m/s. From the Peninsula of Sembulungan (East Java), the propagated litters were transported away from the open ocean and more toward the coastal area of West and South Bali joining other litters originated from other sources along the coastline of Bali and continue moving towards Kuta Area. At day 10, litters from sources along the coastline of Bali reach Kuta area while the litters originated from the Strait of Bali (or litter from Java) arrive in Kuta area at Day 15 with speed less than 0.04 - 0.2 m/s causing an accumulation of litters for both plastics and woods in Kuta area. With our assumption in the set up (1 kg/s of litters), the accumulated litters in Kuta beach reaches 10-20 tonnes of plastics and 20 – 35 tonnes of woods after 15 days (6 – 10 tonnes/day) or nearly similar to the reported daily collected litters (8-10 tonnes) by the local government (The office of waste and park management/Dinas Kebersihan dan Pertamanan).

The larger amount of woods seen during the survey may be caused by the fact that woods materials were easier stranded in the beach than plastic materials. Moreover, our observation to the sources along the coastline of Bali also shows larger amount of wood litters in the river mouth (3 locations out of 5) as shown in Table 4. This also may indicate that large amount of wood litters may come from Bali's coastline instead of Java. According to the National Statistical Bureau (BPS, 2007), the West coast of Bali is less densely populated (< 1000 people/km^2) compared to the heavily populated Java Island where plastics uses are far much larger. Therefore, there are possibility at certain time the stranded litters are dominated by woods as found in the past and in the current studies.
According to our survey results for the seabed litters during west season, the amount of plastics collected from the 6 (six) transect lines in Kuta show 4 (four) time larger compared to the ones collected during transitional season. This findings confirmed stories from the local fishermen who used to fish in the area using nets. They informed us that fishing in the area were difficult due to large amount of plastics instead of fish in their nets. In the cross shore direction, we also observed that seabed litters near the shoreline was more than two times larger than litters collected further from the shoreline. As shown in Fig. 3a, transect lines K2-K42, K4-K3, and K6-K5 were located closer to the coastline (land) and transect line K16-K17, K8-K7, and K15-K14 are located further offshore. During west season (Feb 2016), the transect lines near the coastline account the total collected litters 252 items and 3.3 kg while those from the transect lines further offshore were only 196 items and 1.52 kg. The dominance of inorganic materials found for the seabed litters in the current study is in agreement with similar studies in Brazil (Fernandino *et al*., 2015) and in the Mediterranean (Pasquini *et al*., 2016)

During the transitional season (west season has been weaken) the item and the total amount of litters are equivalent for all transect lines but far much less. This could be related to the fact that most litters were already transported back to the open ocean. The fact that hardly litters found during the transitional season is related to the data of water quality parameters where all parameters were within the standard except for few points where turbidity is high due to mixing processes (Table 3). During the survey of seabed, a large amount of litters was observed in the water column. This was anticipated by the collection of floating litters from the boat. The collected floating litters using the boat and fishing nets resulted in similar trend as the collected litters from the seabed, particularly for the distribution of litters in cross shore direction. As shown in Fig. 8 and Table 2, the amount of litters were 2.5 kg in point 1 (near the shore), 0.5 kg and 0.2 kg further offshore. The dominance type of litters are also plastics in agreement by many authors worldwide (Di-Meglio & Campana 2017; Tutman *et al*., 2017; Basurko *et al*., 2015). High concentration of litters along the coastline indicates the possibility of engineering solution for alternatives of marine litter mitigation. Since we know the area where the distribution is higher than other area, it will be easier to trap and collect litters at certain locations. However, this also has some risks, particularly how to let fish and other living things out of the trap while trapping the litters. Studies on mesh size, structural strength, duration and timing for trapping litters offshore are required for more efficient efforts of cleaning the oceans. For the case of

Bali, the social costs should also be considered before implementing new technology of cleaning the litter offshore since the cleaning of the beach every West Monsoon Season involving many locals who earned benefits from the activities.

Above all, the best effort to clean up the beach from the litters is to prevent people from littering since early age. As shown in our short survey about the social aspect of the locals on littering, most of the people is still not aware on the importance of cleanliness (Fig. 9). Though they agree that the government and some privates had done something to clean up the beach from litters, littering still be considered as “normal” by many Indonesians/Balinese. In general, the culture of putting litter into trash bins still need to be developed in Indonesia and this will take some times. Everywhere in Indonesia, ones may find easily litters/trash not in a proper place. Therefore, for short measures, cleaning the beach, trapping litters offshore and providing infrastructure for waste processes may be a solution. However, for long term, stopping the source of all litters (human) by changing the littering culture of the people is far more important and will have a great impact for the cleaner ocean in the future. This can only be done from early childhood education.

CONCLUSION

Previous studies have shown data and models about the characteristics of marine litters in Kuta area. Current study has added more information and understanding on the processes, particularly for the seabed and floating litters in spatial domain where seabed and floating litters were concentrated near to the coastline and dominated by plastic materials. Marine litter hazards occurring during the west monsoon season was supported by the numerical model involving latest wind data. During transitional season 2015, however, marine litters were not significantly observed and the water quality parameters were still within the standard. The amount of litters during west monsoon season is four times larger than the litters during transitional season. In the meantime, the observation of river mouth along the coastline of West Bali and East Java showed that there are possibility of more wood materials (instead of plastics) transported to beach of Kuta as reported by previous studies.

The concentration of marine litters at certain locations (near the coastline for the case of Bali) made opportunity to build a litter trap system offshore to minimize the amount of litters stranded in the beach. However, more studies are required for the implementation of this technique especially the impact to the marine lives. Above all, the behaviour of the people for not littering (especially into rivers) is more important to prevent litters entering the marine environment. For more comprehensive mitigation in the future, the current research still need more detailed works such as: longer duration of measurement, the standardization of devices (e.g. the nets for floating litters), more sample locations, all seasons measurements, impact on marine lives and social economic impact.

ACKOWLEDGEMENTS

We would like to thank the Research Institute for Coastal Resource and Vulnerability, Ministry of Marine Affairs and Fisheries, Republic of Indonesia, Padang for the 2015 research funding. We also would like to thank the local government of Bali, Dhyana Pura University - Bali, Padjadjaran University - Bandung, I Ketut Gede Arsa, I Made Rampug, I Gede Sandhika, MT, Anom Bayu Santosa and Dr. Agung Santoso for the collection of data, support, suggestion and advice during the visit to Bali.

REFFERENCE

Attamimi, A. (2015). Pemodelan Hidrodinamika Pesisir Pantai Kuta Bali Untuk Analisis Kerentanan Cemaran Sampah. Bachelor Thesis. Program Studi Ilmu Kelautan, Fakultas Perikanan dan Ilmu Kelautan, Universitas Padjajaran, Bandung. 132hlm.

Attamimi, A., Purba, N.P., Anggraeni, S.R., Harahap, S.A., & Husrin, S. (2015). Investigation of Marine debris in Kuta beach, Bali, Presented article in The 1st Young Scientist International Conference of Water Resources Development and Environmental Protection, Malang, Indonesia, 5-7 June 2015

Basurko, OC. Gabiña, G.,Andrés, M. Rubio, A. Uriarte, A. & Krug, I. (2015). Fishing For Floating Marine Litters SE Bay of Biscay: Review and Feasibility Study, Marine Policy 61 (2015) 103–112.BPS, (2007). Peta Kepadatan Penduduk Menurut Basic Grid Square – Pulau Jawa dan Bali, Developing system of small area statistics, Badan Pusat Statistic and JICA 2007.

Butterworth, A. Clegg, I. & Bass, C. (2012). Untangled – Marine Debris: A Global Picture of the Impact on Animal Welfare and of Animal-Focused Solutions. London: World Society for the Protection of Animals.

Di-Méglio, N. & Campana, I. (2017). Floating Macro-Litter along the Mediterranean French Coast: Composition, Density, Distribution and Overlap with Cetacean Range. Marine Pollution

Bulletin (2017), http://dx.doi.org/10.1016/j.marpolbul.2017.02.026 (in- press).

Fernandino, G. Elliff, CI. & Silva, IR. (2015). Degree of Pollution by Benthic Litter in Beaches In Salvador, Bahia, Brazil, Scientia Plena Vol. 11, Num. 03 2015, www.scientiaplena.org.br

GESAMP (2016). Sources, Fate and Effects of Micro Plastics in the Marine Environment: Part Two of a Global Assessment. (Kershaw, P.J., and Rochman, C.M., eds). Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 93, 220 p.

Jambeck, JR. Geyer, R. Wilcox, C. Sieger, TR. Perryman, M. Andrady, A. Narayan, R. & Law, KL. (2015). Plastic Waste Inputs from Land into the Ocean. Science 13 Feb 2015, Vol. 347, Issue 6223, pp. 768-771, DOI: 10.1126/science.1260352

Lebreton, LCM. Greera, SD. & Borreroa, JC. (2012). Numerical Modelling of Floating Debris In the World's Oceans, Marine Pollution Bulletin 64 (2012) 653–661.

National Oceanic and Atmospheric Administration Marine Debris Program (2014). Report on the Entanglement of Marine Species in Marine Debris with an Emphasis on Species in the United States. Silver Spring, MD. 28 pp.

OSPAR - Oslo and Paris Conventions for the Protection of the Marine Environment of the North-East Atlantic (2009). Marine litter in the North-east Atlantic region. London: OSPAR Commission. Publication number 386/2009.

OSPAR - Oslo and Paris Conventions for the Protection of the Marine Environment of the North-East Atlantic (2010). Guidline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area. London: OSPAR Commission.

Pasquini, G. Ronchi, F. Strafella, P. Scarcella, G. & Fortibuoni, T. (2016). Seabed Litter Composition, Distribution and Sources in the Northern and Central Adriatic Sea (Mediterranean). Waste Management (2016), http://dx.doi.org/10.1016/j.wasman.2016.08.038.

Putra, A. & Husrin S. (2016). Kualitas Perairan Pasca Cemaran Sampah Laut Di Pantai Kuta Bali, Jurnal Ilmu dan Teknologi Kelautan Tropis - ITKT – IPB (in press).

Ryan, P.G. Moore, C.J. van Franeker, J.A. & Moloney, C.L. (2009). Monitoring the Abundance of Plastic Debris in the Marine Environment. Philos Trans R Soc Lond B Biol Sci 364(1526): 1999-2012.

TIME (2011). Holidays in Hell: Bali's Ongoing Woes, By Andrew Marshall / Bali Saturday, Apr. 09, 2011. Link: http://content.time.com/time/world/article/0,8599,2062604,00. html, last access: May, 22nd 2017.

Tutman, P. Kapiris, K. Kirinčić M. & Pallaoro, A. (2017). Floating Marine Litter as a Raft for Drifting Voyages for Planes Minutus (Crustacea: Decapoda: Grapsidae) And Liocarcinus Navigator (Crustacea: Decapoda: Polybiidae), Marine Pollution Bulletin, http://dx.doi.org/10.1016/j.marpolbul.2017.04.063 (in- press).

Wang, J. Kiho, K. Ofiara, D. Zhao, Y. Bera, A. Lohmann, R. & Baker. MC. (2017). The First Global Integrated Marine Assessment: World Ocean Assessment 1 – Chapter 25: Marine Debris, Cambride University Press, UK.

Werner, S. Budziak, A. van Franeker, J. Galgani, F. Hanke, G. Maes, T. Matiddi, M. Nilsson, P. Oosterbaan, L. Priestland, E. Thompson, R. Veiga, J. & Vlachogianni, T. (2016). Harm Caused by Marine Litter. MSFD GES TG Marine Litter -Thematic Report; JRC Technical report; EUR 28317 EN;DOI:10.2788/690366.

Yosafat, F.E. (2012). Pergerakan Sampah Lautan dengan Pendekatan Model Trajektori Partikel di Perairan Selat Bali (Thesis Magister). Bandung: Institut Teknologi Bandung. 2012.

Yunanto A. Suganda, E. Soesilo, TEB. & Hanggono, A. (2014). Modeling Abundance and Control of Litter on Kuta Beach, Bali, Indonesia, International Journal of Sciences: Basic and Applied Research (IJSBAR) (2014) Volume 15, No 1, pp 708-729.