OTEC
Vol.26 (2021), 111～123

Preliminary Design of Multi-Purpose Waste Management Ship for Indonesian Waters

Rizky IRVANA[*1,2], Abdul ROKHIM[*1,2] and Arif FADILLAH[*1,2]

[*1] Department of Naval Architect, Darma Persada University
Taman Malaka South Street, East Jakarta, Jakarta, 13450, Indonesia
[*2] Darma Persada Maritime Research Center
Taman Malaka South Street, East Jakarta, Jakarta, 13450, Indonesia

Abstract

The increasing number of people and their activities have an impact on the marine environment. The sea becomes vulnerable to the threat of pollution originating from human activities, such as waste, either industrial or household waste, oil spills, or bad behavior in disposing of waste. Currently, the world is faced with the problem of plastic waste pollution in the sea. Indonesia is one of the largest plastic waste contributor countries in the world after China. 80 percent of the plastic waste enters through the river and the remaining 20 percent is due to the behavior of throwing garbage directly into the sea. If there is no serious handling, marine pollution will increasingly have an impact on the economic and tourism sectors, disrupting the life of marine biota, ecosystems, and human health. As an archipelagic country, Indonesia requires extraordinary efforts to monitor the ocean territory. One of the most important things is to keep the waters free from litter. Of course, this ideal condition is difficult to achieve because of the large amount of water activity, both on the high seas and the ports. As many as 400 million tons of plastic are produced worldwide annually for various purposes, including as a wrapping material because it is lightweight and functional. This was quoted from a report by the World Economic Forum entitled White Paper on Plastics Circular Economy and Global Trade published in July 2020. Unfortunately, most of the plastic ends up as waste and has the potential to damage the environment, including in waters. The total waste entering the sea in 2020 is estimated to reach 521,540 tons, of which around 12,785 tons came from activities in the Indonesian sea. This number has taken into account waste leakage data from activities at sea which is calculated through the approach to the number of trips for passenger ships and fishing boats. One of the important factors in controlling marine debris is activities at the port. Not only from land activities but activities from passing ships also contribute to the problem of marine pollution and even oil spills from the ship. From the problems above, a ship is needed that can reduce solid or liquid waste. Therefore, the author plans to design a multipurpose waste management ship that can solve them. The hull of the garbage ship is made using a catamaran hull because apart from being more efficient in terms of resistance and stability, the ship's deck will also have a wider width than a monohull hull so that it can load more equipment.

Key words : Catamaran Ship, Garbage Ship, Multi-Purpose Ship, Waste Ship, Waste Management Ship

1. Introduction

The number of activities from human activities does not infrequently produce material in the form of residual objects continuously and will make piles in nature. Waste objects that are not useful and unwanted in the long term will be a serious problem that must be prevented and taken seriously. The remaining objects that are disposed of by nature can be called garbage (Law No. 8 of 2018). The staggering rate of waste generation due to industrialization, urbanization, and population growth has raised a pressing problem regarding environmental damages and human health hazards, especially in developing nations. Nowadays, due to the lack of proper infrastructural services and serious effort by responsible authorities and governments, many cities in the world are overwhelmed by Municipal Solid Waste (MSW) problems

Received date: 2021.11.30
E-mail of corresponding author: rizky4568@gmail.com

(Tsai et al., 2020). Accelerating industrialization (Zhao et al., 2016), urbanization (Singh, 2019), population (Muneeb et al., 2018) and economic growth and change in lifestyle and consumption patterns lead to a tremendous increase in the generation of MSW (Yao et al., 2019). Based on forecasting, the global MSW generation may increase from 1.3 billion t per year in 2010 to 2.2 billion t per year by 2025 (Hoornweg and Bhada-Tata, 2012).

In addition to waste on the surface, there is also a lot of garbage at the bottom of the water which causes shallow water depths due to the accumulation of so much garbage in one place, but the main source of this buildup is soil erosion caused by high rainfall or waves and also can result in sedimentation in the form of mud at the bottom of these waters. As the shipping industry develops and the process of globalization accelerates, shipping has become one of the most important means of transportation for many countries, assuming an important role in global cargo transportation. 90% of the volume of world trade is transported by ships (Oliveira et al., 2019). Ships produce pollution that damages the aquatic environment and the surrounding atmosphere (Martin et al., 2019).

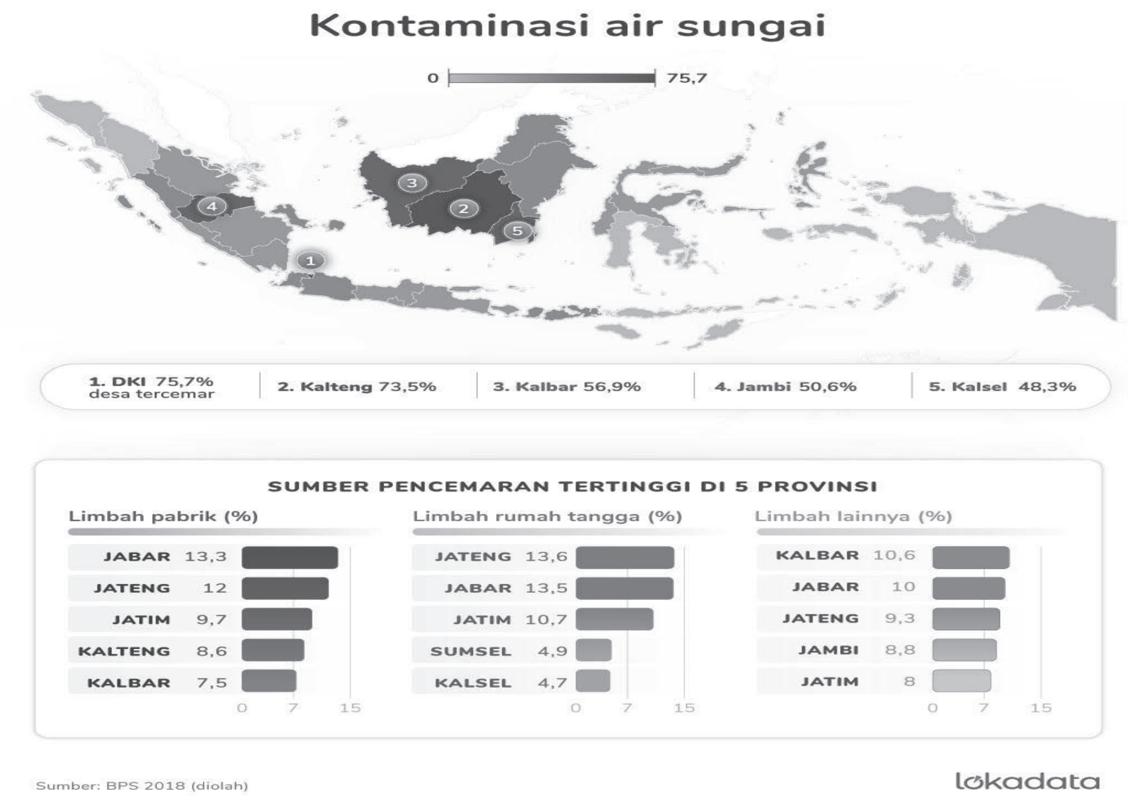

Fig. 1 River contamination in Indonesia.

The main pollution includes oil pollution, air pollution, domestic waste pollution, and waste pollution. According to statistics, 11% of waste discharged into the ocean comes from shipping (Sherrington et al., 2016), and ship waste is a substantial part of ship-sourced pollution (To and Kato, 2017). Ship waste is generated during ship operations, navigation, and berthing, including packaging materials, plastic products, food scraps, and domestic waste. The amount and category of ship waste vary greatly during a voyage, as does the amount of ship waste during the delivery of different types of cargo. For example, when transporting general cargo, the waste is mainly packaging material, for every 100–150 tonnes of cargo transported, 1 tonne of waste is generated. When transporting bulk cargo, for every 100 tons of cargo transported, 70 kg of waste is generated. Marine pollution is an important environmental problem of our time. Different pollutants such as oil, sewage, plastics, and hazardous chemicals enter the marine environment and affect marine organisms, ecosystems, human health, and the economy (Beiras, 2018). It is estimated that about 80% of marine debris is on land (UNEP, n.d.a), with regional fluctuations; at the same time, marine-based sources are receiving increasing attention, both because of their quantity, but also because of the damage to marine life and its negative impact on the economy (GESAMP, n.d.)

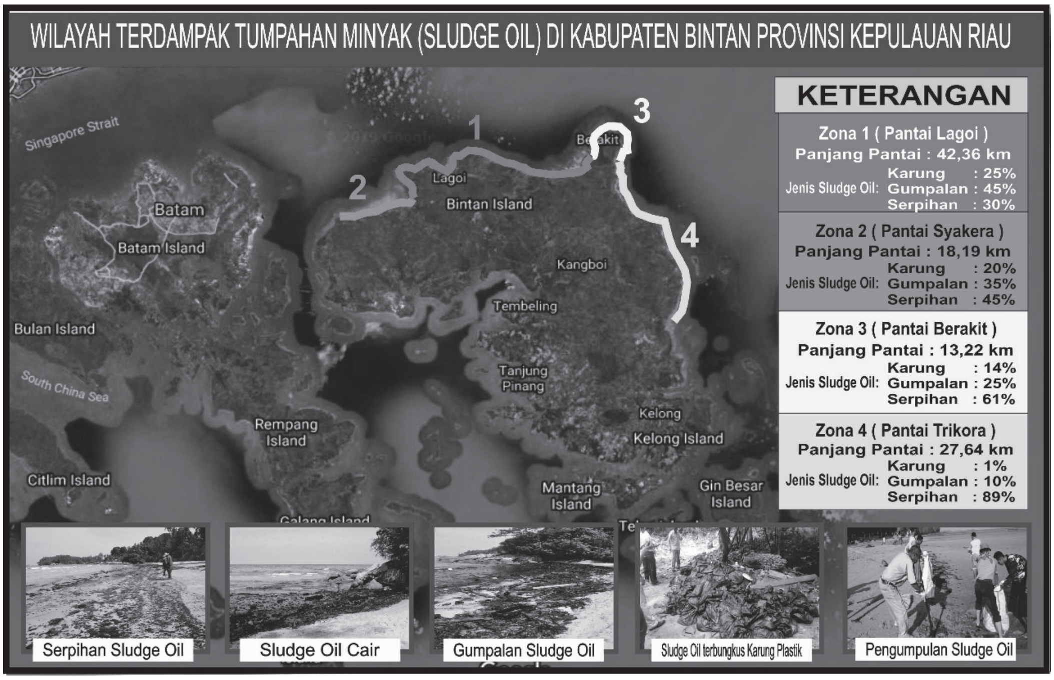

Fig. 2 Oil spill along the coastline in Indonesia.

Ship waste mainly comes from wrapping and binding materials during cargo transportation, waste during daily ship repair and maintenance, and domestic waste during the daily life of ship crews. According to the estimates of a Chinese scholar, the monthly amount of shipwreck generated by a 14,100 TEU container ship with 23 crew on the route from far east to northwest Europe is estimated as follows: (1) The amount of plastic waste generated per person per day is approximately 0.005 m^3 (mainly including compressed purified water bottles, beverage bottles, and self-purchased food packaging bags, etc.), it is estimated that the crew generates about 0.115 m^3 of plastic waste per day and 3.45 m^3 of plastic waste per month (30 days), food plastic bags produced by the kitchen and plastic packaging materials produced by the deck, engine room, and other departments is about 1.0 m^3 per month. This means that the total plastic waste generated by the ship is 4.45 ^{3}3 per month. (2) The vessel generates approximately 0.7 m^3 of compressed ship waste per month, including empty paint buckets, empty chemical buckets, empty cleaning buckets (plastic), empty cooking bottles, wine bottles, and used batteries, etc. According to calculations, the total amount of ship waste generated by the ship is about 8.6 m^3 per month.

Ship waste can cause major damage to the ocean. Toxic substances contained in ship waste can affect the survival of aquatic organisms and the waste itself can degrade water quality and disrupt the water purification process itself. In addition, some of the ship's waste will be deposited on the seabed, thus changing the living conditions of aquatic organisms (Basar et al., 2018). Plastics in ship waste are the most dangerous for marine organisms and very dangerous for the oceans (Alfonso et al., 2021). Plastic is very difficult to decompose and can be mistaken for food by marine animals (Basu, 2017). Only by taking action to manage, control, and recycle waste, its access to the marine environment can be greatly reduced (Rangel-Buitrago et al., 2020). Marine pollution caused by shipwrecks is getting worse. How to deal with it is no longer a problem that must be faced by only one country, but a problem that must be a concern of the world. Passenger ships operate in all the oceans of the planet, often in pristine coastal waters and sensitive marine ecosystems. They tend to concentrate their activities in certain coastal areas and repeatedly visit the same ports, creating significant cumulative impacts on a local scale due to population density (Toneatti et al., 2020). A passenger ship is a floating city that accommodates more than 300 passengers and crew members to serve passengers and maintain the ship. Currently, there is a trend of increasing ship size (Cerveny et al., 2020). Passenger ship operators provide facilities to their passengers like hotels. Consequently, passenger ships have the potential to generate all kinds of waste (EPA, 2008; Sanches et al., 2020). Copeland (2011) calculated the average waste production for a cruise ship with 3000 people during a voyage during a week as follows: 795 m^3 of waste, 3785 m^3 of greywater, 95 m^3 of oily water, and 8 tonnes of solid waste.

This study aims to design a mode of water transportation, namely ships that can overcome or reduce solid or liquid waste from land, sea, or ship waste, therefore the author plans to design a multipurpose catamaran waste management ship that can solve the above problem. This research chose a ship design with a catamaran hull because the catamaran compared to a monohull ship has a wider deck, has better stability, is more comfortable because the angle of swing is smaller (Herijono, 2017). The design of a ship with a catamaran hull because the catamaran compared to a monohull ship has a wider deck, has better stability, more comfortable because the angle of swing is smaller. (Nugraha, 2017). To reduce air pollution or water pollution produced from this ship, one of them is to use renewable energy sources, one of which is sunlight as an energy supporting lighting on ships. Solar energy is one of the energies that can create a Zero Emission Vehicle (ZEV) because it can be converted into several forms of energy, one of which is the helioelectrical process. The Helioelectrical process is the process of converting solar energy into direct electrical energy by using photovoltaic devices or solar panels made of semiconductor materials, electric power is one of the best candidates for reducing air pollution and marine pollution. (Sardi, 2019).

2. Methodology
2.1 Spiral Design

The process of making a ship design is an iterative process, which must go through every stage that must be met to get a good and optimal ship design. This design is described in the spiral design (the spiral design). The spiral design divides the entire process into 4 stages, namely concept design, preliminary design, contract design, and detail design (Watson, 1998)

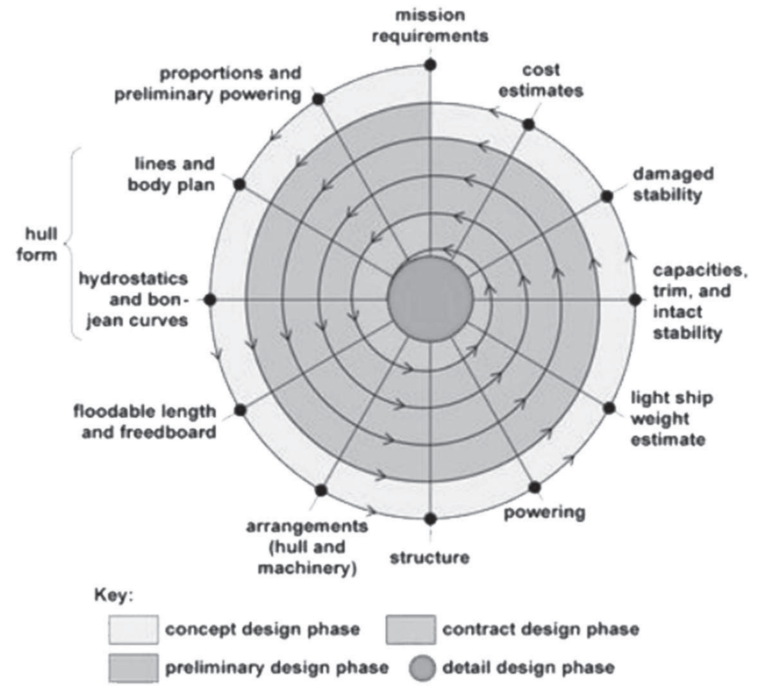

Fig. 3 Spiral Design.

2.1.1 Concept design

Concept design or ship design concept is an advanced stage after the Owner's requirement. The concept of ship design is the task or mission of the designer to define an object to meet mission requirements and comply with existing constraints or problems. Concepts can be made using approach formulas, curves, or experience to make initial estimates that aim to get estimates of construction costs, ship machinery costs, and ship equipment and supplies costs. The results of this design concept stage are generally in the form of drawings or sketches, either partially or completely.

2.1.2 Preliminary design

The second stage in the design process is the preliminary design. Preliminary design is a further technical endeavor that will give more detail to the design concept. Concerning the spiral diagram, this preliminary design is the second iteration or can be said to be the second path on the spiral diagram. What is meant by detail includes features that have a significant impact on the ship, including the initial approach to the costs that will be required. Examples of adding details are the calculation of the longitudinal strength of the ship, the development of the midship section of the ship, a more accurate calculation of the weight and center of gravity of the ship, draft, stability, and others.

2.1.3 Contract design

The contract design stage is an advanced stage after preliminary design, namely the stage of developing ship design in a more detailed form that allows shipbuilders to understand the ship to be built and accurately estimate all shipbuilding costs. The main purpose of the design contract is the creation of a document that describes the ship to be built. Furthermore, the document will be the basis of the contract or development agreement between the ship-owner and the shipyard.

2.1.4 Detail design

Detail design is the last stage of the ship design process. At this stage, the results from the previous stages are developed into a more detailed working drawing as a whole. This stage includes all the plans and calculations needed for the ship's construction and operation process. The bulk of this work is the production of working drawings required for the production process.

2.2 Linear Regression

The method used in linear regression is the Least Squares Method. The purpose of this method is to make the errors that occur as small as possible, as shown below. The trick is to square the error (D^2), where;

$$D^2 = \left(y1 - f(x1)\right)^2 + \left(y2 - f(x2)\right)^2 + \left(yn - f(xn)\right)^2 \quad (1)$$

From the regression form:

$$Y = a + bx \quad (2)$$

a and b must be made such that for D^2 to be a minimum, so that:

$$\partial D^2/\partial a \ = 0 \quad (3)$$

$$\partial D^2/\partial b \ = 0 \quad (4)$$

$$b = \frac{n\sum xiyi - \sum xi \sum xi}{n\sum xi^2 - (\sum xi)^2} \quad (5)$$

$$a = y - bx \quad (6)$$

After obtaining a and b, then enter them into the regression equation y = a + bx. To predict whether the regression line that we have made already has the smallest possible error, it is necessary to calculate a coefficient called the correlation coefficient (r). The correlation coefficient has a value from 0 - 1. The closer the value to 1, the better r. The formula for calculating r is:

$$r = \sqrt{\frac{Dt^2 - D}{Dt^2}} \quad (7)$$

Where:

$$Dt^2 = \sum_{i=1}^{n}(yi - y)^2 \quad (8)$$

$$D^2 = \sum_{i=1}^{n}(yi - a - bxi)^2 \quad (9)$$

2.3 Ships stability

To calculate the stability of the ship designed using the A.N-Krylov method to obtain appropriate results using the standards provided by IMO. On a ship, whether in an upright position or tilted to an angle, two forces act: The weight of the ship (W) and the buoyant force (Fb) are equal but act in opposite directions. The weight of the ship is the gravitational force measured in Newtons, the buoyant force which is also measured in Newtons is also called the displacement (force). For the displacement (mass) of the ship, measured in tons the symbol Δ is used. For the underwater volume of the hull, called the volumetric displacement, the symbol ∇ is used. (A.N-Krylov)

$$F_B = g\Delta = \rho g\nabla \quad (10)$$

The initial metacentric height is equal to the difference between the metacentric radii and the distance between the center of buoyancy (B) and gravity G.

$$GM_0 = BM_0 - GB \quad (11)$$

The transverse metacenter radius at each inclination is also called the metacenter difference.

$$r_\varphi = B_\varphi M_\varphi = \frac{dI_{WL}}{d\nabla} \quad (12)$$

The transverse metacentric radius for the upright position is:

$$r_0 = BM_0 = \frac{I_{WL}}{\nabla} \quad (13)$$

Where: Iwl = moment of inertia of the waterplane.
The relationship between the two equations is:

$$r_\varphi = r_0 + \nabla \frac{dr_0}{d\nabla} \quad (14)$$

The static stability arm can be calculated using the following equation:

$$GZ = y_{B\varphi} \cos\varphi + (z_{B\varphi} - Z_B)sin\varphi - GBsin\varphi \quad (15)$$

Where : $y_{B\varphi}, z_{B\varphi}$ are the coordinates of the center of buoyancy.

The equation $BN = y_{B\varphi} \cos\varphi + (z_{B\varphi} - Z_B)sin\varphi$ is called the righting arm of form and BC = BG sinφ is called the righting arm of weight. GZ can also be calculated by the formula:

$$GZ = y_{B\varphi} \cos\varphi + Z_{B\varphi} - KGsin\varphi \quad (16)$$

For a small inclination angle, the relationship between GZ and the inclined angle is assumed to be directly proportional, then the erection moment can be calculated by:

$$M_R = g\Delta\, GM_0\varphi \quad (17)$$

The above formula is called the metacenter formula of stability. For all angles of inclination, the erection moment can be calculated by:

$$M_R = g\Delta\, GZ \quad (18)$$

The curve of the straightening arm must match the appropriate characteristics. An example of the GZ value at the slope angle $GZ20^0$, $GZ30^0$, $GZ40^0$, $GZ\ ^0m$, from the slope angle m must match. The difference between the straightening arm and the angle of inclination is called the generalized metacenter height:

$$h_\varphi = \frac{d(GZ)}{d\varphi} = B_\varphi M - y_{B\varphi}sin\varphi + Z_{B\varphi}cos\varphi - KGcos \quad (19)$$

Geometrically, this is equal to the distance between the metacenter M and the projection of G in the direction of the buoyant force, Z

$$E_R = \int_0^\varphi M_R\, d\varphi = g\Delta \int_0^\varphi GZd\varphi \quad (20)$$

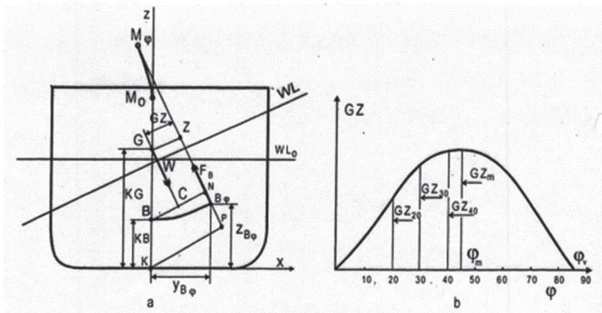

Fig. 4 GZ Curve.

2.3 Ships resistance

To find out the total resistance of the designed ship, this study uses the Insel & Molland method and the slender body in the maxsurf program which then the results obtained will be compared. Manual calculations by using the following formula:

The total resistance of the ship for each catamaran hull:

$$C_{total} = (1 + \beta k) \times Cf + \tau \times Cw \quad (21)$$

Where:

C_F = Friction Resistance

$1 + \beta k$ = Catamaran viscous resistance interference

τ = Catamaran wave resistance interference

C_W = wave resistance

For Catamaran Viscous Resistance Interference:

$$1 + \beta k = [\beta \times (1 + k)] - \beta + 1 \quad (22)$$

To calculate the total resistance of the catamaran used the following formula:

$$Rt = 0{,}5\ x\ \rho\ x\ 2\ x\ WSA\ x\ V^2 x\ Ctot \quad (23)$$

2.4 Number of solar panel

To calculate the need for how many solar panels are used onboard the calculation below is used:

$$Number\ of\ Panel = \frac{total\ electricity\ needs\ on\ the\ ship(wh)}{Solar\ panel\ power\ peak\ (w)\ x\ sun\ exposure\ time\ (h)} \quad (24)$$

The duration of solar radiation is estimated to be 5 h. The amount of power produced by all solar panels in 1 h is:

Number *Solar Panel* (Pieces) × *Power* Peak *Solar Panel* (W) = ... (Wh) (25)

The amount of power generated by all the solar panels in 5 hours is:

Amount of Power 1 h × Duration of irradiation for 5 h = ... (Wh) (26)

2.5 The energy produced by solar panels

Solar PV (Photovoltaic) energy is defined as solar energy generated by Solar PV modules.

$$Epv(t) = \frac{Ppv}{1000}.\eta s.\eta c.x1.\frac{Irr(t)}{Gstc}; t = 0,1,2, \dots 24 \quad (27)$$

Where PPV is the Solar PV module's peak wattage in watts; Irr is solar radiation in kW/m2 and GSTC is radiation at standard test conditions equal to 1 kW/m2. ηs is the efficiency of the Solar PV system which is the energy loss due to converters, cables, temperature, etc. ηc is the charging efficiency which is the energy loss due to the process of charging Solar PV energy to the battery, and x1 is the number of Solar PV modules.

2.6 Number of battery

To calculate the need for how many batteries are used onboard the calculation below is used:

$$Number\ of\ Battery = \frac{total\ electricity\ needs\ on\ the\ ship(kW)}{Battery\ Capacity\ (kW)} \quad (28)$$

2.6 Battery Energy

Other factors that affect battery capacity such as temperature, charging current, or discharging are not considered.

$$Ebatt = \frac{Vbatt.Cbatt.x2}{1000.\eta d} \quad (29)$$

Where Vbatt is the nominal battery voltage in volts and Cbatt is the battery capacity in Ampere-hours, ηd is the battery discharging efficiency which represents energy loss during the energy discharge process, and x2 is the number of batteries.

4. Data
4.1 Comparison ship data

Ship data is needed to find the main dimension of the ship to be designed. With the data of the existing ship, it will be converted from Eq. (1) to (8). The following provides 20 comparison ship data:

Table 1. Data of comparasion ship

No	Name of Ship	Ship Dimension				Ratio		
		L (m)	B (m)	H (m)	T (m)	L/H	B/T	L/B
1	The aqua View	12	5,5	1,8	0,5	6,667	11,000	2,182
2	BT T 405	13,6	7,7	2,7	1,1	5,037	7,000	1,766
3	BT A-307	12,8	6,7	2,4	1,3	5,333	5,154	1,910
4	Bahia 46	14	7	2,9	1,3	4,828	5,385	2,000
5	Salina 48 Evolution	14,3	7,7	2,8	1,1	5,107	7,000	1,857
6	Nautitch 47	14,5	7,6	3	1,2	4,833	6,333	1,908
7	Yellow Cat II	14,9	6,7	2,2	1,1	6,773	6,091	2,224
8	Fastford	12	4,5	1,8	1,2	6,667	3,750	2,667
9	Whitemorph	14,8	5,4	1,8	1,2	8,222	4,500	2,741
10	Gulftslansd	14,6	6,7	2,1	1,1	6,952	6,091	2,179
11	Gulfts Urveyor	14,6	5,2	1,9	1,3	7,684	4,000	2,808
12	Ikatere	14,2	5,7	2,4	1,2	5,917	4,750	2,491
13	Deodar II	14,5	6,9	1,9	0,8	7,632	8,625	2,101
14	Bobkat1250	12	5	1,5	0,5	8,000	10,000	2,400

15	Clipper III	14,4	6,6	1,8	0,7	8,000	9,429	2,182
16	Catamaran Ha1245	12,5	4,4	1,5	0,4	8,333	11,000	2,841
17	Catamaran ferry	10,5	5	1,7	0,5	6,176	10,000	2,100
18	Passenger Ferry	8,76	4	1	0,4	8,760	10,000	2,190
19	19 m catamaran ferry	16	6,9	2	1	8,000	6,900	2,319
20	Cat Taxi	9,8	5,8	1	0,3	9,800	19,333	1,690

The ship data taken is combined data from a commercial ship in the form of a catamaran hull. There is also a garbage ship that uses the catamaran hull in the data above.

4.2 Main dimension correction

After the main dimension of the ship is obtained, then corrections are made to the main size with values taken from the table below.

Table 2. Main Size Correction

Correction	Method	Value
L/B1	Insel & Molland	5,9 - 15
B/H	Insel & Molland	0,7 - 4,1
S/L	Insel & Molland	0,19 - 0,51
S/B1	Insel & Molland	0,9 - 4,1
B1/T	Insel & Molland	0,9 - 3,1
B1/B	Insel & Molland	0,15 - 0,3

If the correction does not meet, then the calculation of the main dimension of the ship must be repeated until all components are met

4.3 Stability Criteria

This is a correction standard for calculating ship stability from the IMO (International Maritime Organization). If several criteria are not met, the calculation will be repeated by improving the placement of the equipment on the ship until it gets a good center of gravity.

Table 3. Stability Criteria

Code	Criteria	Value	**Units**
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30	3,1513	m.deg
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40	5,1566	m.deg
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 30 to 40	1,7189	m.deg
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.3: Angle of maximum GZ	25,0	deg

5. Result and discussion
5.1 Main dimension calculation

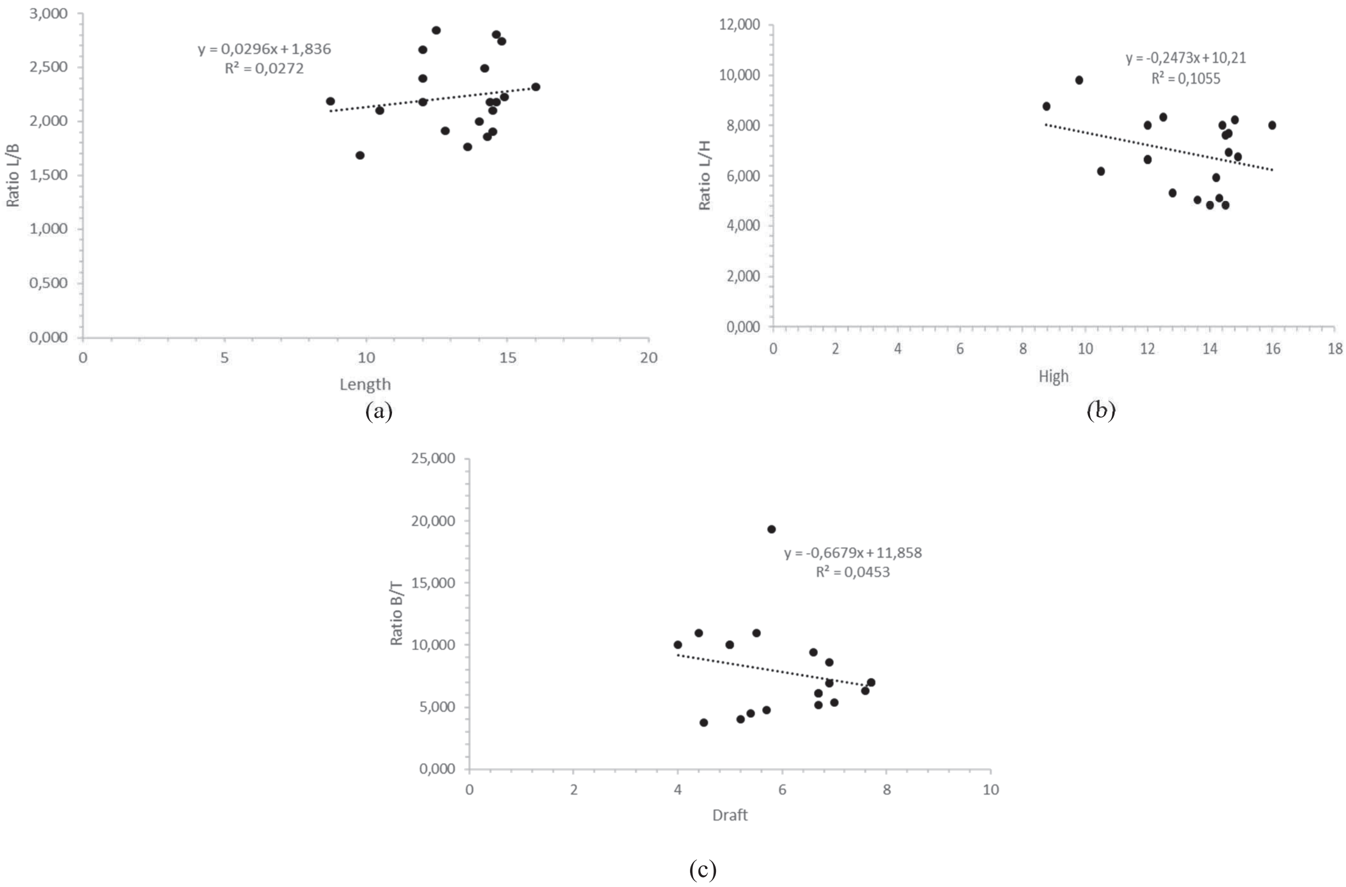

Fig. 5 (a), (b), (c) Resul of linear regression.

The results of the calculation of equations 1-8 are expressed in graphical form using the help of Ms. excel. There are 3 charts, namely the L/H, L/B, and B/T ratio charts. Each of these ratios will produce the main dimensions of the ship, there are length, width, height, and draft. Then the main dimension is corrected against table 2. If it meets the criteria, then the calculation can be continued to the next stage. If it does not meet the criteria in table 2, then the main dimension calculation is repeated. The other main dimensions and the weight of the ship are calculated using the Maxsurf software which is presented in the table below.

Table 4. Main dimension of ship

Dimension	Value	Unit
L	20,000	m
B	8,250	m
H	3,800	m
T	1,300	m
Cb	0,422	
Cp	0,734	
Cw	0,802	
Cm	0,576	
Weight	53	Ton

5.2 Design, equipment, and facility

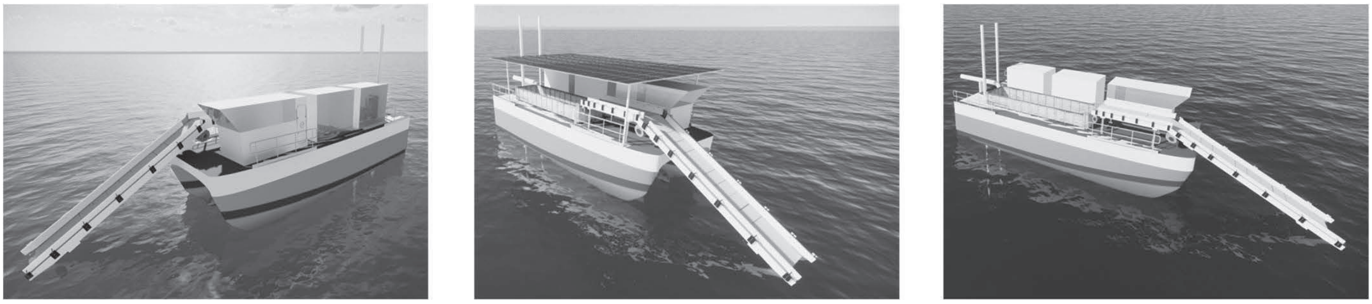

Fig. 5 Design of ship.

Since this research is still in the early design stage, there will be several design options. Each design has a different capacity but has the same function. The front of the ship has a navigation deck, which is where the ship's steering wheel is located. Just like other commercial ships, this ship also follows the international rules in terms of safety, namely SOLAS (Safety of Life at Sea). According to SOLAS, the equipment that must be on the navigation deck is the Echo Sounder Radio, Compass, Radar, GPS, etc. By using equation (1) this ship is equipped with a solar panel with a capacity of 1.8 kWh. Depending on the placement of the solar panels and the number of them, the capacity may vary. Also equipped with a battery by following equation (1) the battery capacity is 2x30 kWh. Just like with solar panels, the capacity of this battery can change according to the electricity needs on the ship. The tool for picking up the waste uses a conveyor belt with a power of 0.5 kW at a speed of 20m/min. The ship is equipped with a garbage bin with a capacity of $27m^3$ for one trip. If it is full it will be dumped at the nearest port.

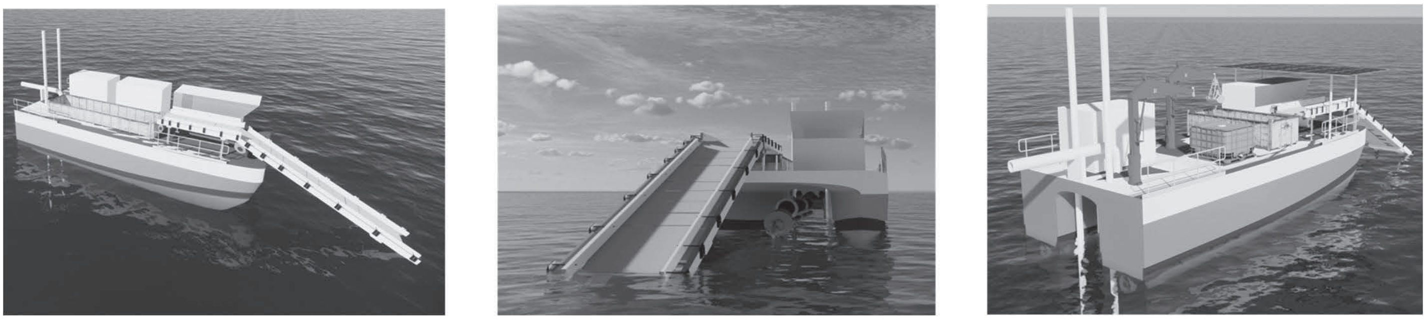

Fig. 6 Design of ship.

Behind the navigation deck, there is a warehouse for storing oil booms, oil skimmers, and dispersants. The oil boom is used to widen the oil spill that occurs from inside the ship. where the suction capacity of the oil skimmer is 10l/m. An oil skimmer is a tool to suck up oil spills. If the spill is too dense, an oil dispenser can be used first. It was explained earlier that this ship is a multipurpose ship, this ship is also equipped with a cutter section type dredger. The capacity of the dredging itself is 1m3/h. The capacity of the oil spill storage tank is 1000l for one trip. This ship is equipped with a powerful 330 HP engine for a maximum speed of 15 knots. The speed when picking up trash, which is only 6 knots with the required power is 15 HP.

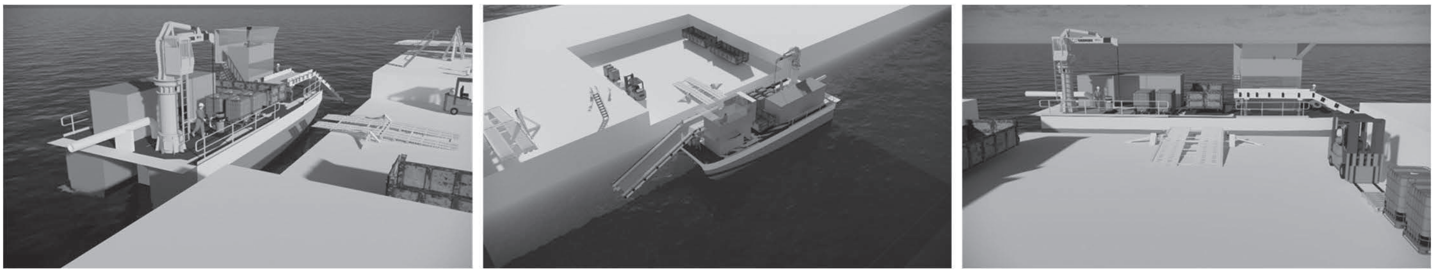

Fig. 7 Design of ship.

This is another one-of-a-kind design. There are several cranes to help operate the oil boom, and other cranes can assist with garbage collection. If the oil and garbage tanks are full, they must be disposed of at the nearest port. A reception facility is a place in the port where to store the remains and waste from the ship.

6. Conclusion

From the results of the research above, several conclusions can be drawn

1. The results of the calculation of the main dimensions of the vessel meet all the specified correction criteria with a crew of approximately 3 to 4 people. The main dimension of the ship can still be changed according to the needs and capacity because this is still an early design.
2. The results of the calculation of the ship's resistance at a speed of 15 knots is 32 Kn and the required power is 319 HP.
3. The available designs are still subject to change because this is an initial design including the existing facilities on the ship.
4. The stability of the ship will be made into 2 conditions when the condition is a full load and the condition is an empty load and the results will be corrected according to the rules of the IMO (International Marine Organization) Code on Intact Stability.
5. Alternative renewable energy not only uses solar energy with solar panels but can also use other energies.

References

Law No. 18 of 2008 concerning Waste Management, Government of the Republic of Indonesia

Alfonso, M.B., Arias, A.H., Men´endez, M.C., Ronda, A.C., Marcovecchio, J., 2021.Assessing threats, regulations, and strategies to abate plastic pollution in lac beaches during covid-19 pandemic. Ocean Coast Manag. 208.

Basar, E., Sivri, N., Ugurlu, O., Soenmez, V.Z., 2018. Potential impacts of oil spill damage around the planned oil rigs at the black sea. Indian Journal of Geo-Marine Sciences 47 (11), 2198–2206.

Basu, B., 2017. Microplastic pollution is devastating our oceans. Sci. Cult. 83 (1/2) 61–62.

Beiras, R., 2018. Marine Pollution: Sources, Fate and Effects of Pollutants in Coastal Ecosystems. Elsevier, p. 408. https://doi.org/10.1016/C2017-0-00260-4.

Cerveny, L.K., Miller, A., Gende, S., 2020. Sustainable cruise tourism in marine world heritage sites. Sustainability 12 (2), 611. https://doi.org/10.3390/su12020611.

Copeland, C., 2011. Cruise Ship Pollution: Background, Laws and Regulations, and Key Issues, Maritime Law: Issues, Challenges and Implications. Nova Science Publishers Inc, Resources and Environmental Policy, Congressional Research Service, United States, pp. 155–183.

EPA, 2008. Cruise Ship Discharge Assessment Report, Washington D.C.: U.S. Environmental Protection Agency, Oceans and Coastal Protection Division, Office of Wetlands, Oceans, and Watersheds. Office of Water.

Herijono, Boedi. 2017. Design of Dredger Ship for Downstream Normalization of Kalimas River. 2017.MASTER. 215-219

Hoornweg, D., Bhada Tata, P., 2012. What a Waste: a Global Review of Solid Waste Management. World Bank, Washington, DC.

Insel, M., Molland, A., 1992. Investigation Into The Resistance Components of High Speed Displacement Catamarans

Martin, G., Alan, J., Murphy, Kayvan, et al., 2019. Evaluation of environmental performance indices for ships - sciencedirect. Transport. Res. Transport Environ. 73 (C), 152–161.

Muneeb, S.M., Adhami, A.Y., Jalil, S.A., Asim, Z., 2018. Decentralized bi-level decision planning model for municipal solid waste recycling and management with cost reliability under uncertain environment. Sustain. Prod. Consum 16, 33-44.https://doi.org/10.1016/j.spc.2018.05.009.

Nugraha, Asep Kurniawan. et al. 2017. Analysis of the Performance Improvement of MV Catamarans. Laganbar uses Centerbulb and Bulbous Bow with Computation Fluid Dynamic Method. Journal of the Department of Marine Engineering, Faculty of Engineering, Diponegoro University. page 50

Oliveira, D.D., Silva, E., Pereira, S.S., Lopes, A.P., Swan, L., Costa, B.S., et al., 2019. Monitoring vessel traffic in rio de janeiro port area: control of marine antifouling regulations. Ocean Coast Manag. 182 (Dec.), 104997.1-104997.6.

Rangel-Buitrago, N., Williams, A., Costa, M.F., de Jonge, V., 2020. Curbing the inexorable rising in marine litter: an overview. Ocean Coast Manag. 188, 105133.

Sanches, V.L., Aguiar, M.R.D.C.M., de Freitas, M.A.V., Pacheco, E.B.A.V., 2020. Management of cruise ship-generated solid waste: a review. Mar. Pollut. Bull. 151, 110785. https://doi.org/10.1016/j.marpolbul.2019.110785

Sardi, July. 2019. Solar Panel Technology as a Power Generation for Lighting Systems on Fishing Vessels Journal of Research and Community Service UNSIQ. Vol 7 No 1:21-26

Sherrington, C., Darrah, C., Hann, S., Cole, G., Corbin, M., 2016. Study to support the development of measures to combat a range of marine litter sources. Report for European Commission DG Environment. Return to ref 2016 in article.

Singh, A., 2019. Managing the uncertainty problems of municipal solid waste disposal. J. Environ. Manag. 240, 259-265.

To, N.T., Kato, T., 2017. Solid waste generated from ships: a case study on ship-waste composition and garbage delivery attitudes at haiphong ports, vietnam. J. Mater.Cycles Waste Manag. 19 (2), 988–998.

Toneatti, L., Deluca, C., Fraleoni-Morgera, A., Pozzetto, D., 2020. Rationalization and optimization of waste management and treatment in modern cruise ships. Waste Manag. 118, 209–218. https://doi.org/10.1016/j.wasman.2020.08.018.

Tsai, F.M., Bui, T.-D., Tseng, M.-L., Wu, K.-J., 2020. A causal municipal solid waste management model for sustainable cities in Vietnam under uncertainty: a comparison. Resour. Conserv. Recycl 154 (104599). https://doi.org/10.1016/j.resconrec.2019.104599.

V. Semyonov-Tyan-Shansky, “Statics and Dynamics of the Ship – Theory of Buoyancy, Stability and Launching”, Peace publishers, Moscow.

Watson, D. 1998. Practical Ship Design : Elsevier

Yao, X.-Z., Ma, R.-C., Li, H.-J.,Wang, C., Zhang, C., Yin, S.-S.,Wu, D., He, X.-Y.,Wang, J., Zhan, L.-T., 2019. Assessment of the major odor contributors and health risks of volatile compounds in three disposal technologies for municipal solid waste. Waste Manag. 91, 128-138.

Zhao, J., Huang, L., Lee, D.-H., Peng, Q., 2016. Improved approaches to the network design problem in regional hazardous waste management systems. Transp. Res..part E Logist. Transp. Rev. 88, 52-75.

Available at UNEP (n.d.)a. Land-Based Pollution, 2021. UN Environment Programme. accessed on November 2021. https://www.unenvironment.org/explore-topics/oceans-seas/what-we-do/working-regional-seas/land-based-pollution

GESAMP (n.d.). Sea-based sources of marine litter. available at. http://www.gesamp.org/work/groups/wg-43-on-sea-based-sources-of-marine-litter.assessed on November 2021.