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DEVELOPMENT OF BALLAST WATER DISCHARGE PROFILE ESTIMATION

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ABSTRACT

BWM Convention used to control and monitoring invasive species content in ballast water. This convention also regulates ballast water discharge, to reduce the risk of the spreading of harmful aquatic organism from one region to other region, and poses serious ecological and health problems. Ballast water spreading is depending on the amount of maritime traffic. The increasing of maritime traffic in Indonesia Port also will impact to the spreading of ballast water discharge. This analysis will conduct to identify and estimate the ballast water discharge profiles in Tanjung Perak Port, develop the software application for ballast water discharge profile estimation in port, estimate the pump capacity for establish the ballast water treatment, and know the relation of ballast water discharge profiles and the ratification of BWM Convention in Indonesia. Ballast Water Discharge Assessment (BWDA) model is used to calculate the estimation of ballast water discharge in Tanjung Perak Port and the secondary data used to identify the harmful species content from origin country. The results of this final project are estimation of quantity of ballast water discharge and its possibilities profile. Several countries become the biggest origin country that discharge ballast water. Ballast water discharge profiles estimation can be used to establish monitoring mechanisms to prevent ballast water pollution in Indonesia sea, and make the long-term risks assessment in ballast water management.

Keywords: Ballast, Discharge, Harmful, Profile, Software, Species, Water

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1. INTRODUCTION

Commercial vessels are generally built to transport cargoes or passengers. In case, the condition of vessel is not fully load with cargoes or passenger additional weight is needed to make sure the stability of vessel. Nowadays, the material of additional weight on vessel is using water which implemented in ballast water system.

Ballast water issue is very complex. By this time, IMO adopted one of the International Convention Ballast Water Management Convention (BWM Convention) for control and monitoring of ballast water. This convention also regulates ballast water discharge, to reduce the risk of the spreading of harmful aquatic organism from one region to other region, and poses serious ecological and health problems. Every sea has the characteristic of the harmful species. The species can be disappeared or even breed. Several harmful microorganisms can be producing their own poison to attack the other species in terminal [1]. Since September 2017, Indonesia already ratified BWM Convention to minimize the damage of the marine environment especially in the port area. In Indonesia the data to support the development of ballast water management is still minimum.

Figure 1 shows the amount of loading and unloading cargo, the trend line shows that loaded cargo and unloaded is increase. The amount will be linear with the amount of maritime traffic in Indonesia Port. And it means the spreading of ballast water will also increase. Ballast water transferred by international vessels will be concentration in this analysis because the content of ballast water from other state will significant different than domestic vessels. This analysis will be conduct to identify the profile of ballast water discharge in Tanjung Perak Port (Jambrud Terminal, Surabaya Container Terminal, and Lamong Bay Terminal) as the identified port. There are several loading-unloading cargoes data and DWT vessels that will be used to estimate the volume of ballast water discharges from ships with international routes.

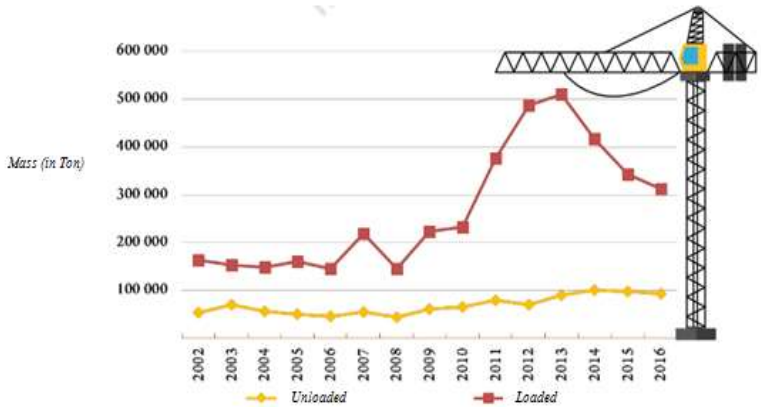


Figure 1 Loading and Unloading of International Voyage at Indonesia Port [2]

In last few years, the using of software application to help the working of human is increasing, that is indicate the growth and quality increase on human life. There are several applications that used especially what is often used in this digital era is Web-based applications. In this final project, the software application using web-based will develop to

help estimation for ballast water discharge profile in other port. The software will be providing the database and the report for several times in one terminal.

The objectives for this study is to identify and estimate the ballast water profile in Tanjung Perak Port, develop the software application for estimate the ballast water discharge in port, and estimate the pump capacity of ballast water treatment. Ballast water discharge profiles estimation can be used to establish monitoring mechanisms to prevent ballast water pollution in Indonesia sea and make the long term risk assessment in ballast water management. [4]

2. MATERIAL AND EXPERIMENTAL SETUP

2.1. Materials

The material for quantify ballast water discharge in Port is using Ballast Water Discharge Assessment Model principle and it will be shown in **Figure 2.**

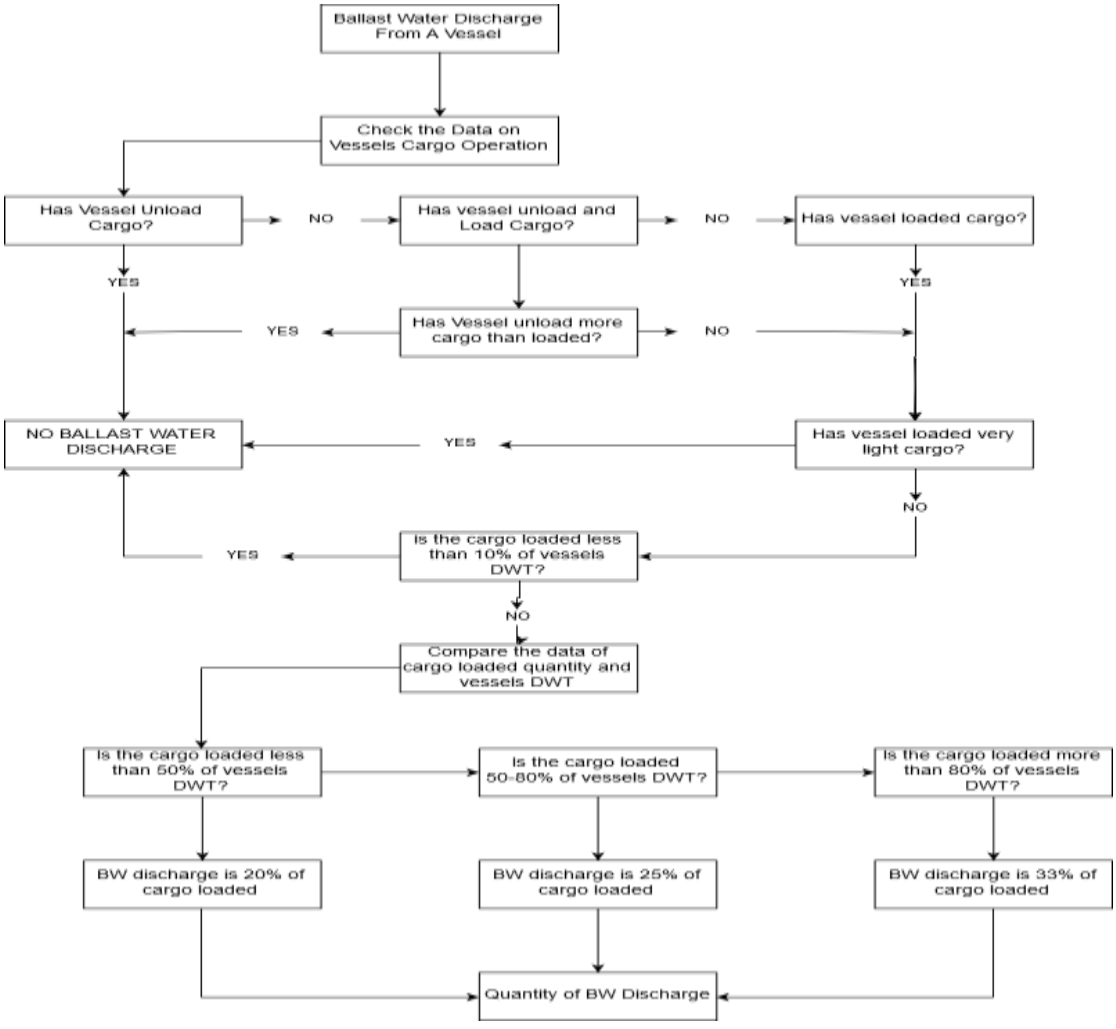


Figure 2 Ballast Water Discharge Assessment Model [3]

2.2. METHODS

The methods to develop of ballast water discharge profile estimation in port will be done in several methods as follows:

2.2.1. Problem Identification

This first stage identified the problems of ballast water discharge profile. The object of research taken in the final project is ballast water discharge profile in Tanjung Perak Port especially in Jambrud Terminal, Petikemas Surabaya Terminal, and Lamong Bay Terminal.

2.2.2. Literature Study

The next stage is to conduct a literature study with aim to explaining the depth of review, summarizing the basic theory, general and specific reference, and obtaining various other supporting information related to the final project. In this final project, the authors conducted a literature study on Ballast Water Management, Ballast water discharge estimation, ballast water discharge assessment model, the harmful aquatic species that carried by ballast water, and environmental stuides especially in port. Furthermore the authors also conduct a literature study for develop the software application web base for estimate the ballast water on port.

2.2.3. Data Collecting

The data needed for the analysis with the Ballast Water Discharge Profiles (BWDP) method in this final project is quantitative data to making the analysis for the next step. The data that collect to done this final project as Port Call for ship which have an International routes, DWT of ship and Cargo Operation.

2.2.4. Data Analysis

Data analysis done in several step by analysis and process the data that collected in Tanjung Perak Port. The step to anyaze the data are identify the maximum DWT of the ship. Then, identify the amount of loaded and unloaded cargoes in Tanjung Perak Port especially at three terminal, Jamrud Terminal, Petikemas Surabaya Terminal and Lamong Bay Terminal. After that, determine wether the ship discharge ballast or not and calculate the estimation of ballast water discharge using the basic priciple of ballast water discharge assessment model in previous research and shown in Figure 3.

2.2.5. Quantity of Ballast Water Discharge

Quantifiying of ballast water discharge profile will done after data analysis. ballast water discharge profile will indicate with the total volume of the ballast discharge profile in the port (in ton) and calculate the average, maximum and minimum of ballast discharge profile each month (in m3)

2.2.6. Indentification Content of Ballast Water Discharge Profile

Indentified content of ballast water discharge profile is done with use the secondary data from several previous research about the water ballast discharge content in several origin port.

2.2.7. Develop the Software Application for Ballast Water Discharge Profile

After doing the analysis of the ballast water discharge profile in Tanjung Perak Port, aouthor develop the calculation to making the software application for estimate the ballast water discharge profile that can be implement to other port and estimate the total ballast discharge profile for the future marine traffic.

2.2.8. Software Verification

After develop the software, the next step is making the verification of the software, the verification will do with upload the cargo operation data from the one year in port and upload to the software, then compare with the manual calculation then identify the result of ballast

water discharge profile. If the result doesn't match, then recheck the manual calculation and the source coding of the software application.

3. RESULTS AND DISCUSSIONS

3.1. Identification Ballast Water Discharge Volume

There are 3425 ships call in Jamrud Terminal in January 2012 until August 2018, 5850 ships call in Container Surabaya Terminal in January 2012 until October 2018, and 746 ships call in Lamong Bay Terminal in January 2016 until October 2018. In each terminal the information about maximum DWT data is not available. Then, DWT data collected from marine traffic and vessel finder.

Based on the basic principle in **Figure 2,** ballast water discharge will happen in the ship that doing a loading cargoes and loading –unloading process that the amount of cargo that will load is more than the cargo that unload and the amount of the differences of cargoes weight is bigger than 10% of DWT of the ship, if the difference is less than 10% that means the ship will assume didn't discharge ballast water. The percentage (%) of quantity ballast water discharge can be estimate using this approximately of maximum DWT of the ship and the amount or weight of the cargo that will be load on the ship 20% average of ballast discharge will discharge if the cargo loaded to ship is 10%-50% of ship total DWT, 25% average of ballast discharge will discharge if the cargo loaded to ship is 50%-80% of Ship total DWT, and 33% average of ballast discharge will discharge if the cargo loaded to ship is more than 80% of Ship total DWT

Figure 3. shows the comparison between total cargo that loaded and the total ballast water that discharge in port in tons. The higher cargo which loaded the higher ballast water that discharge because the percentage (%) of quantities ballast water that discharge is depend the amount of the quantities of the loaded cargo.

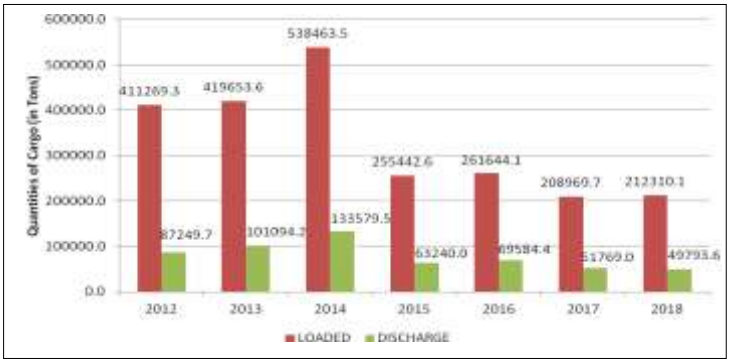


Figure 3 Quantities of Cargo loaded and Ballast Water Discharge in Tons in Jamrud Temrinal

In Jamrud Terminal the type of ship are include bulk carrier, container, general cargo, and chemical/oil Tanker. For Container Surabaya Terminal and Lamong Bay Terminal the types ship that doing loading unloading process just Container ship. The information for the capacity cargo for container ship in Petikemas Surabaya Terminal and Lamong Bay Terminal is not available. So, the author grouping the ship due to the LOA within LOA 50-100m, 101-150m, 151-200m, 201-250m, 251-300m and >300m.

As shown in **Figure 4.** the higher ship that discharge ballast water in Jamrud Terminal is chemical/oil tanker and bulk carrier during 2012-2018. The volumes of discharge ballast water around 58861.5m3 for chemical/oil tanker in 2014 and 43433.47 m3 for bulk carrier type in 2018.

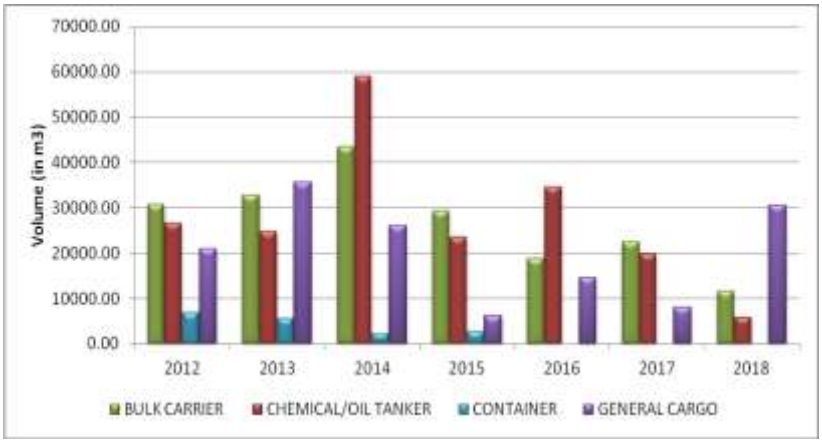


Figure 4 Volume Ballast Water Discharge In M3 By Vessel Type In Jamrud Terminal

In Container Surabaya Terminal. the higher size of ship that discharge ballast water is the ship with LOA 151-200m that discharge ballast water around 849189,2m3 and size 201-250m that discharge ballast water around 244579.3 m3. Then, the higher volume ballast water discharge in Lamong Bay Terminal is coming from the ships which have size 201-250m that discharge water about 314630.5m3 in 2018. This result is shown in **Figure 5** and **Figure 6.**

The principle of BWDA model was conducted for all type of ship but excluding the passenger ships because BWDA model is based on the cargo operation. [5]. Determine the ballast discharge profile per month will be calculated in cubic metric. The calculation of water ballast discharge per month is to identify the trend line amount of water ballast discharge volume in the terminal. This step can be useful to consider the size and capacity of water ballast treatment facility in port. Planning the capacity for ballast treatment facilities with port based shall be meet the demand of water ballast discharge then the facilities can be handle the highest flow rates and volume to be treated and received. Volume and frequency of ballast water discharge are important also for planning the capacities of Port State Control (PSC) activities. The result of the calculation will be shown in the **Table 1.**

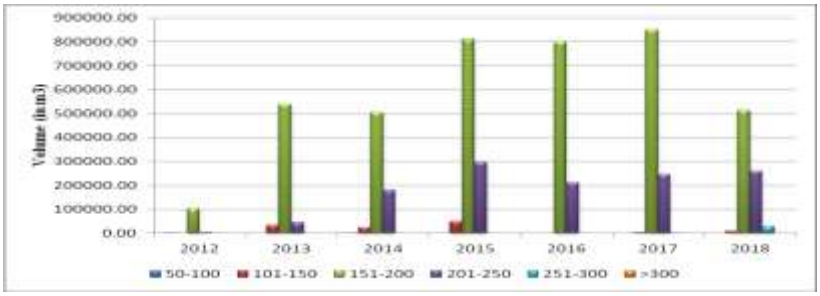


Figure 5 Volume Ballast Water Discharge in Petikemas Surabaya Terminal by LOA of Ship

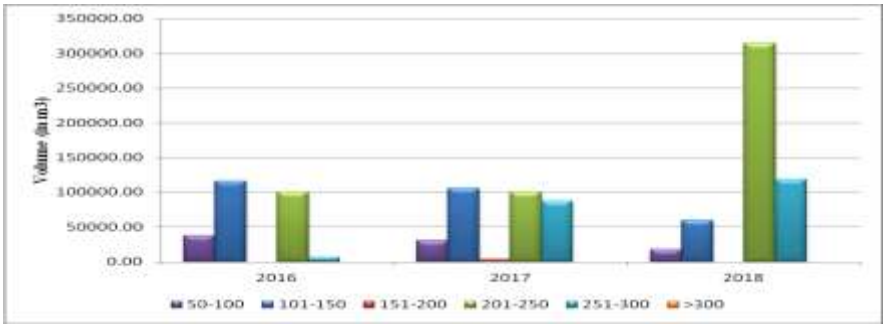


Figure 6 Volume Ballast Water Discharge in Lamong Bay Terminal by LOA of Ship

Table 1 Monthly profiles of ballast water discharge in Jamrud Terminal in 2014

Month	Volume*	Count*	Max*	Min*	Average*	Med*	SD*
Jan	24275	10	6149.2	195.2	2427.5	1609.7	2340
Feb	24610.4	10	8853.0	169.7	2461	1010.7	3121
Mar	11153.1	7	3941.9	169.7	1593.3	1536.5	1242
Apr	13973.2	7	6704.6	216.7	1996.2	1365.8	2155
May	17084.5	12	7268.2	169.7	1423.7	987.3	1916
Jun	10373.7	9	2926.8	250.1	1152.6	1219.5	845.1
Jul	9232.7	8	3632.7	169.7	1154.0	922.4	1150
Aug	2762.5	2	2091.8	670.7	1381.2	1381.2	1004.
Sep	6140.6	5	3267.3	228.4	1228.1	376.3	1355.
Oct	4415.8	4	1762.1	497.5	1103.9	1078	675.1
Nov	2260.2	2	1919.	341.2	1130.1	1130	1115.
Dec	4381.8	4	1609.7	634.1	1095.4	1068.9	516.2

3.2. Identification of Ballast Water Discharge Profile based on the Origin Port

Identification ballast water discharge profile in this research is using the secondary data from several previous researches. Identified the ballast water discharge is done by collecting the origin port of the ship data for each Terminal. Origin port data got from the operational report in each terminal. The origin port information is in the form of several port codes depend on the country of the port. the origin port will be grouping based on the origin country and totalize the volume water ballast discharge based on the origin country.

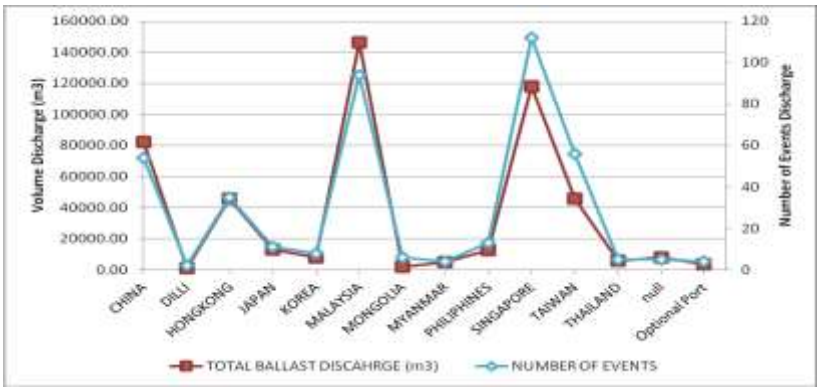


Figure 7 Comparison the Volume of Ballast Discharge.

Figure 7 shows graph between the total volume water ballast discharge in m3 and the number of events of discharge ballast in Jamrud Terminal from January 2012 until August 2018. **Figure 7** also shows the higher of volume ballast water discharge is came from Singapore with the total volume around 117753.54 m3, Malaysia around 146234.2 m3, Taiwan around 45962.02 m3, China 82237.94 m3 and Hongkong around 82237.94m3. Those countries are the big 5 origin country which frequently discharge ballast water in Jamrud Terminal. Total volume water ballast discharge and the number of events of discharge ballast in Terminal Petikemas Surabaya (TPS) from January 2012 until October 2018 with total number of ship call with International voyage are 5850 ships call. The big 5 origin country in TPS are Taiwan with total water ballast discharge around 1077275.4 m3, Singapore around 2819075.3m3, Malaysia around 1266119m3, Korea around 116810.56m3, and Hongkong around 67935.49m3. in Terminal Lamong Bay from January 2016 until October 2018. For three years, the big 4 of origin country with the higher amount of water ballast discharge is

came from Timor Leste with total volume of water ballast discharge around 335331.95m3, China around 238884.48m3, Malaysia around 230995.7m3, and Korea with 170819.2 m3.

This step is using the secondary data from several previous researches on the origin country but unfortunately the research in several countries is not found.

Table 2 Concentration of Virus Species Indicator in Ballast Water Sample in Several Origin Ports [6]

ORIGIN PORT	DETECTION IN MPN/M3					
	V.parahaemolyticus	*V.vulnifucus*	*V.Cholera*	*E.Coli*	*Enterococcus*	total coliform
YANTIAN	ND	ND	ND	ND	400000	510000
NINGBO	90000	1100000	ND	430000	6490000	5470000
CHIWAN	>1100000	>1100000	20000	100000	100000	61310000
TAIWAN	ND	ND	ND	100000	ND	520000
SINGAPORE	120000	ND	60000	630000	1890000	5100000

From **Table 2** show Port of Singapore detected with several harmful microorganisms. The result shows on harbour water is contains *V.parahaemolyticus, V.cholera, E.coli, Enterococcus* and several coliforms in MPN/100mL. In the estimation of total ballast water discharge which has origin country Singapore in Jamud Terminal is 117753.54m3 and 2819075.3 m3 in Terminal Container Surabaya.

The aquatic harmful species in Taiwan seawater contents shows that the water is contains *E.*Coli. There are many previous research and study about seawater content in China. The result shows that in China seas contains around of *V.parahaemolyticus, V.vulnifucus, E.coli, Enterococcus, Aeromonas Hydrophila, Plesiomonas Shigelloides, Brevundinamonas Diminuta, Pseudomonas Doudoroffi, Mycobacterium sp, Acinetobacter sp, Bacillus cereus, Bntorobater sakazakii, Escheria coli , V.Alginolyticus, V. carchariae, V.Flufialis, V.Hollisae, V.metschnikovii, V.Mimicus, V.Furnissii , V.damsela Non-Agglutinable Vibrio, Salmonella sp, Staphylococcus Aureus* [8].

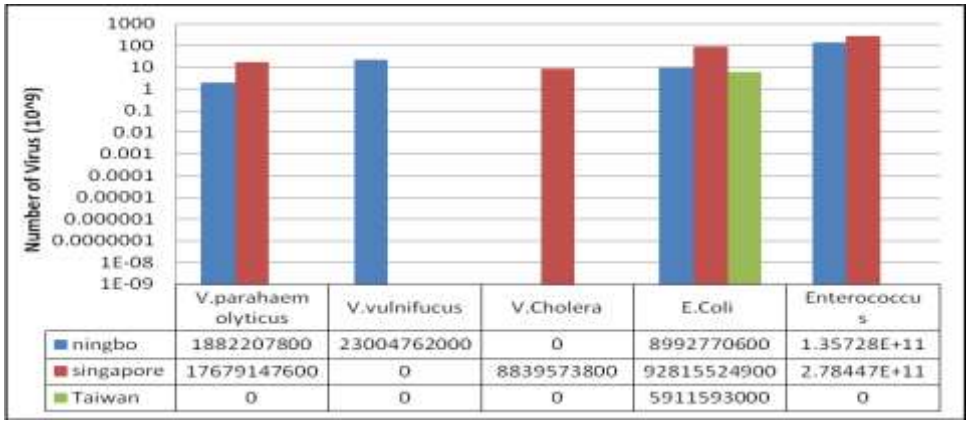
Table 3 Concentration of Virus Species Indicator in Ballast Water Sample from Busan Ports

ORIGIN PORT	DETECTION IN MPN/M3									
	Marimonas	*Celeribacter*	*Roseophage*	*Pelagibacter*	*Choristoneura Occidentalis Granulovirus*	*Mycobacterium phage Breeniome*	*Prochlorococcus*	*Chrysochromuliana Erica Virus Isolate*	*Bacillus phage Mater*	*Synechococcus*
BUSAN	5.1	2.6	0.5	0.4	0.4	0.2	0.2	0.2	0.2	0.2

As shown in **Table 3** the number of events and total volume ballast water discharge with Korea as the origin Country is around 116810.56m3 in Terminal Container Surabaya, and 170819.2m3 in Lamong Bay Terminal. In the previous research, the content of Korea seas is taking sample in Port of Busan. The result of the research shows that the seawater contains 51% of *Marimonas phage P12026*, 26% of *Celeribacter phage P12053L*, 5% *Roseophage SIO1*, 4% of *Pelagibacter phage HTVC008M*, 4% of *Choristoneura Occidentalis Granulovirus*, 2% of *Mycobacterium phage Breeniome*, 2% of *Prochlorococcus phage P-*

TIM68, 2% of *Chrysochromuliana Erica Virus Isolate*, 2% of *Bacillus phage Mater*, and 2% of *Synechococcus phage S-MbCM100* [7].

The number of virus that spreading in Tanjung Perak port calculated with multiplying the total volume ballast water discharge per origin port with the secondary data that available in previous report. This estimation is limited with the availability of the data. The estimation just done with the ship which has origin port from Yantian Port, Ningbo Port, Singapore Port, Taiwan Port and Busan Port.



	V.parahaemolyticus	V.vulnifucus	V.Cholera	E.Coli	Enterococcus
ningbo	1882207800	23004762000	0	8992770600	1.35728E+11
singapore	17679147600	0	8839573800	92815524900	2.78447E+11
Taiwan	0	0	0	5911593000	0

Figure 8 Graph Estimation the Number of Virus (MPN/m3) in Jamrud Terminal 2012-2018

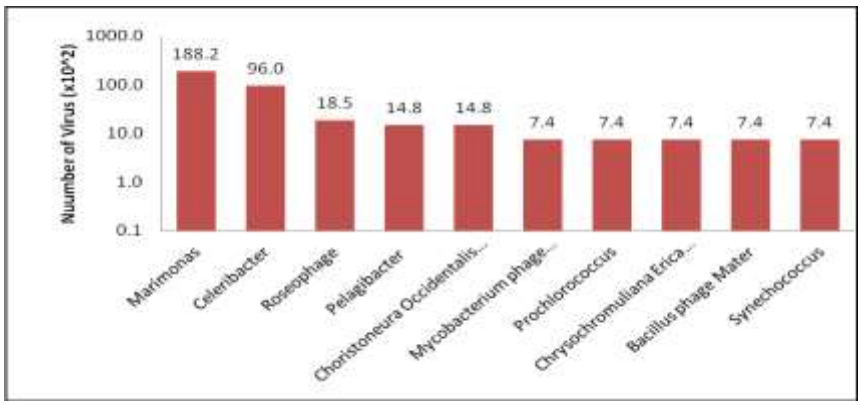


Figure 9 Graph Estimation the Number of Virus (MPN/m3) in Jamrud Terminal 2012-2018 from Busan Port

The data of ballast water discharge profile per origin port as shown in **Figure 8 and Figure 9**, Tanjung Perak Port as the second busiest of Indonesia Port is already contaminated by the ballast water discharge from several countries. From the secondary data, several origin ports are content by harmful aquatic species which danger for the ecosystem and human life. It is shows that treatment for ballast water is needed before it discharged to the Port in Indonesia.

3.3. Pump Capacity Estimation

Pump capacity estimation is calculating in m3/h. The pump capacity estimation calculated with divided volume ballast water that discharge and the duration of loading unloading.

Table 4 Maximum and Minimum of Pump Capacity Estimation in Jamrud Terminal

YEAR	MAXIMUM (m3/H)	MINIMUM (m3/H)
2012	224.44	1.18
2013	297.67	7.73
2014	109.70	4.24
2015	85.23	4.97
2016	141.50	8.38
2017	70.09	5.00
2018	785.72	3.08

Table 5 Maximum and Minimum of Pump Capacity Estimation in Terminal Container Surabaya

YEAR	MAXIMUM (m3/H)	MINIMUM (m3/H)
2012	381.99	1.13
2013	320.56	40.37
2014	284.68	49.34
2015	465.85	38.81
2016	335.40	60.62
2017	359.24	13.67
2018	612.53	14.69

Table 6 Maximum and Minimum of Pump Capacity Estimation in Lamong Bay Terminal

YEAR	MAXIMUM (m3/H)	MINIMUM (m3/H)
2016	194.97016	5.4721209
2017	1080.3563	2.3050498
2018	492.62	18.706431

3.4. Developing Software Applications

In developing the software with web base application, the first step is defining the web application goal. In this research, the goal is to estimate the ballast water discharge profile in port. How much the ballast water that discharge in one month with input the operational data from the terminal, the amount of the cargo that loaded and the maximum DWT size of the ship that will do the loading unloading process.

First step to make the software application is generating the databased of the existing ship which came to Tanjung Perak Port. After generate the database the next step is design the layout and the interface of the application.

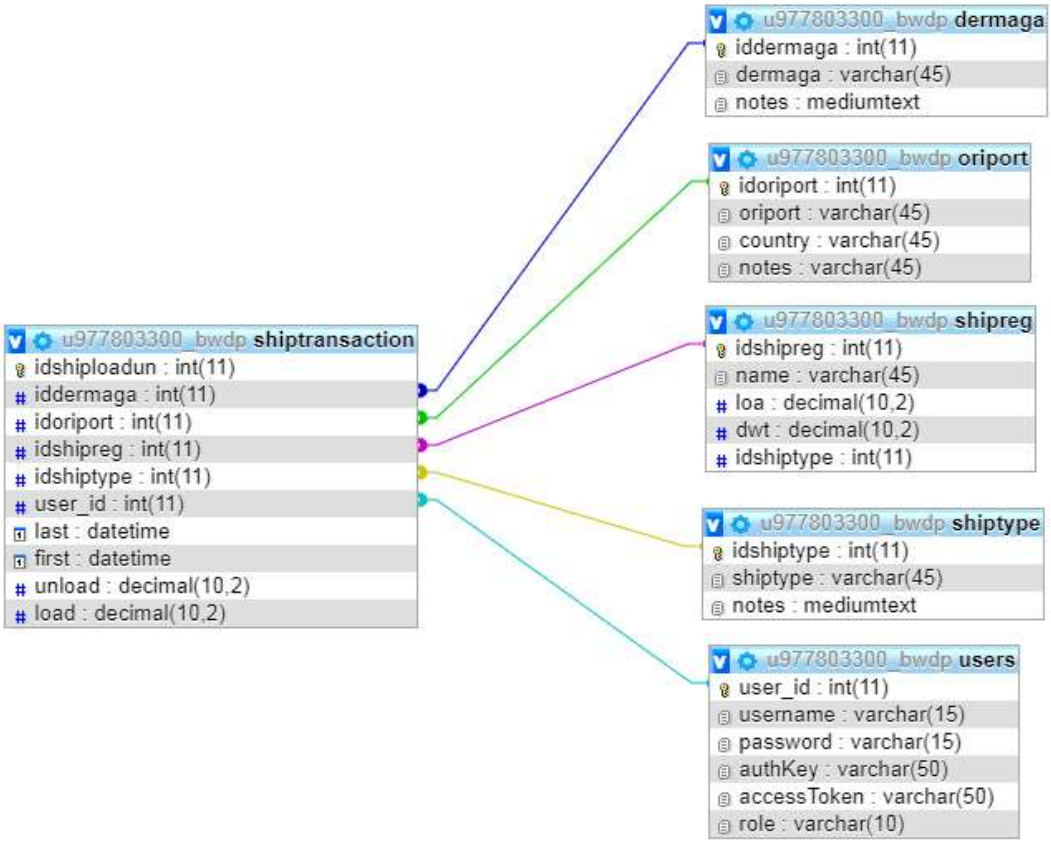


Figure 1 Database Scheme

Figure 10. shows the scheme of the software application principle. The principle of this scheme refers to the principle in BWDA model. The relation between each table, the relation between each column and represent how the information between one column to another in connected.

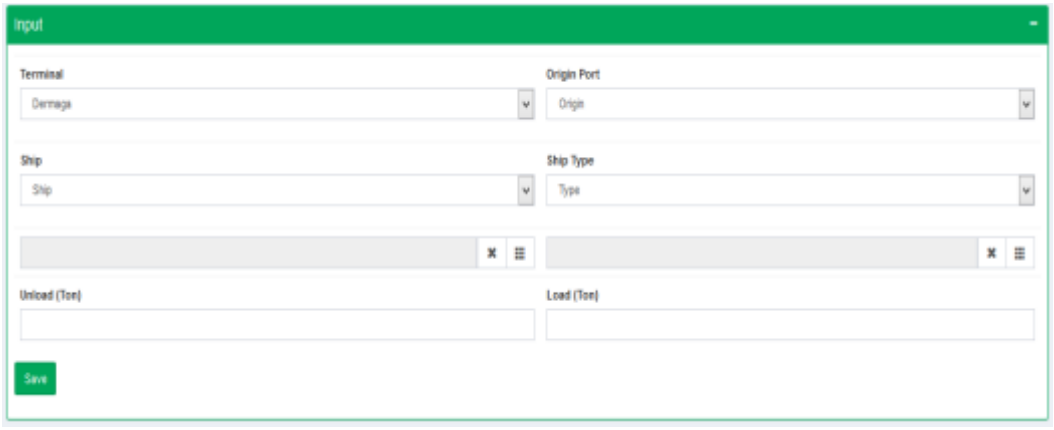


Figure 2 Interface for Input Menu of Software Application

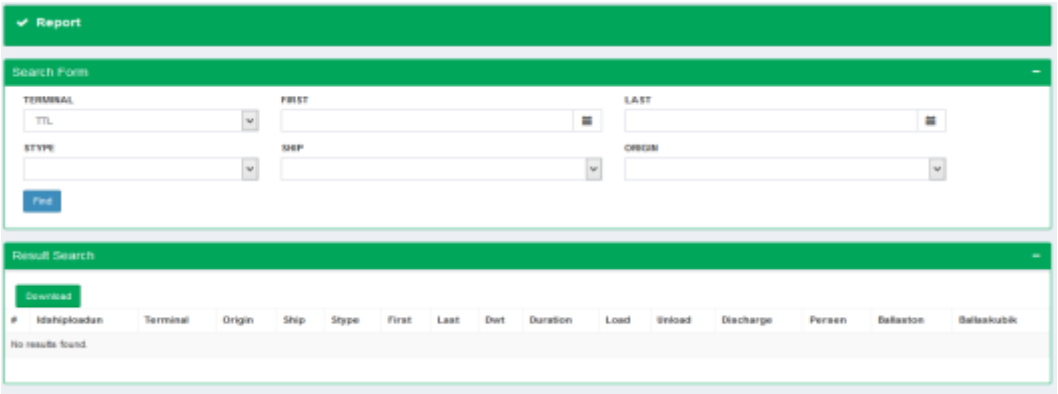


Figure 3 Interface for Report Menu of Software Application

Figure 4 Chart Report of Jamrud Terminal Using Software Application

Several function available in the software applications. The BWDP estimation database is got from the terminal data that already calculated. Report is the facilitation for the operator in port to get the report for the ballast water discharge in port per month or other vulnerable time as shown in **Figure 12** and it can be downloaded**.** If the ship not registered, the operator could register the ship in the menu input in ship load/unload menu as shown in **Figure 11**.

Working principle of this software application is, the user is input the data of loading or unloading cargoes to the input menu. The data that input by user directly input to the ship and ballast water discharge database. Then, the result for each terminal in vulnerable time can be got and printed to know the estimation of the amount of ballast water that discharge on the terminal as shown in **Figure 13**. The software application can be access in www.bwdpestimator.com.

5. CONCLUSION

- Estimation of total water ballast discharge in Tanjung Perak seas during 2012-2018 is reach 7154.4x 10^3m3. In Terminal Jambrud the biggest water ballast discharge comes from chemical/oil tanker ship in Surabaya Container Terminal and Lamong Bay Terminal the biggest water ballast discharge cames from container ship with LOA 151-200m.
- Estimation for ballast water discharge rate for ballast water terminal in 2016-2018 is 1080.3m3/h in maximum capacity and 1.12 m3/h in the minimum capacity.

- The data of ballast water discharge per origin port is shown that Tanjung Perak Port as the second busiest of Indonesia Port is already contaminated by the ballast water discharge from several countries. From the secondary data, several origin ports are content by harmful aquatic species which danger for the ecosystem and human life. It is shows that treatment for ballast water is needed before it discharged to the Port in Indonesia.
- Ballast Water Management Convention is already regulating that the ship which has ballast capacity less than 1500m3 and more than 5000m3 shall be discharge the ballast water with D2 standard (no more 10viable organisms/m3 for the organisms with dimensions not more than 50micrometer, and not more than 10 viable organisms/ml for the organisms with less than 50 micrometers. [9] Due to the result of the estimation in this research, therefore Indonesia government shall be preparing the ballast water treatment facilities to treatment the ballast water discharge before it discharges to the port.
- Software application which using web based can be use for all the port in Indonesia. The working principle is, the operator in port input the loading-unloading data in (ton) and DWT of the ship. The report will show the estimation of volume of ballast water discharge per terminal in vulnerable time. This information can be consideration for establishment of port based ballast water treatment.

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