Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 22 | No. 3 | pp. 1655-1659 | 2023

Original Research Paper | https://doi.org/10.46488/NEPT.2023.v22i03.052 | Open Access Journal

Analysis of Laboratory Experimental Tests on Mixed Oil Disposal (Bilge) from Ships Based on Marpol Annex I: A Case Study of Port of Tanjung Mas Semarang and Port of Tegal

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 15-12-2022
Revised: 11-01-2023
Accepted: 19-01-2023

Key Words:
Bilges water
Mixed oil disposal
Oil water separator

ABSTRACT

Management of marine pollution is a difficult condition to realize, especially the pollution of mixed oil disposal (bilge) resulting from the operation of ships. The oil component has different characteristics compared to the essence of other substances; namely, oil can float on the surface of the water because it has an extra weight the type/density of the essence. The parameters tested in this research are oil/fat content parameters and their extraction according to National Certification Institution 6989.59:2008. Bilge water samples were taken from five commercial ships that leaned on the port and then carried out pre-treatment and post-treatment tests with the liquid separation process in the Oil Water Separator (OWS) device on the ship and then tested in the laboratory to determine the infrared spectrum in the absorption of oil content emissions in water samples, which may not exceed the standard threshold for port water quality, i.e., 5 $mg.L^{-1}$. The sampling tests were carried out for the variables temperature, pH, Total Dissolved Solid (TDS), and oil content obtained values were below the threshold for water quality. To find out the relationship between Group I and Group II, linear regression was used showing the Ho result in reject (0.000<0.05), which means there is a significant relationship between Group I and II.

INTRODUCTION

Indonesia has potential fisheries and transportation resources that are quite promising and can even increase the activities in the port area of fishing vessels and commercial vessels operating at sea. The port is a strategic place for the coastal area, and there are ecological boundaries between the farthest limits from the sea to the land (Puryono et al. 2019). Ports play a crucial role in supporting a country's economic growth, facilitating transportation, and promoting tourism. However, the activities in these waters will undoubtedly have negative impacts. For example, the pollution of the sea, which is interpreted by the presence of waste/dirt from the activities of living things above the waters, was introduced into the marine environment intentionally or unintentionally. These pollutants can change the quality of the water, thus affecting marine ecosystems. Fishing activity with the use of fish traps damages the ecosystem and contributes to the destabilization of maritime climate patterns. Ship collisions pose a risk of oil or cargo spills, which can have devastating consequences for aquatic ecosystems. The pollution caused by waste disposal from ships and the emissions from auxiliary engines and ship propulsion engines further contributes to the degradation of marine environments (State Minister of the Environment 2010).

Furthermore, contamination from oil and liquid waste resulting from ship engine operations is another pollution source affecting marine ecosystems. These various forms of pollution highlight the negative impacts of port activities on the marine environment. Government Regulation of the Republic of Indonesia No.21 in 2021 concerning Pollution Control and or Maritime Environmental Protection explains that preventing pollution from ships is an effort that the captain and crew must make of the ship as early as possible to avoid or reduce pollution from oil spills, toxic liquid materials, dangerous cargo, sewage, garbage, and exhaust gases from ships into the waters and air.

Oil spills/discharges from ships or disposal of engine room wastewater without proper treatment/procedures is one of the sources of oil pollution at sea (Kuncorowati 2018). Even though the intensity of the oil content discharged into the sea is not too large, it is carried out continuously by the operator-ship operators so that it impacts maritime environmental pollution, which disrupts the life of marine ecosystems. Regulation of the Minister of Transportation No. 4 in 2004 concerning preventing pollution from ships limits pollution from ships by requiring each vessel to have a procedure for disposing of waste in the form of liquid or solid originating from ships with criteria based on tonnage. For example, ships with a cargo of 100 GT to 339 GT or having the main propulsion of at least 200 PK must have an Oil Water Separator (OWS) (Ministry of Environment Government of the Republic of Indonesia 2021) Tegal. It has a function to treat water mixed with oil (bilge) from liquid waste disposal from ships before being discharged into the sea not exceeding the required content, i.e., 15 ppm.

The bustling port of Semarang, located in Central Java, experiences a high volume of loading and unloading activities. It has witnessed a rapid increase in traffic, with a diverse and substantial number of tugboat ships. As a result, the port of Semarang has become a preferred choice for many individuals seeking reliable and efficient sea transportation services (Hanjani 2004). Table 1 shows the general conditions of Tugboat ships at Port of Tanjung.

The second research focuses on the Port of Tegal, situated in the northern coastal area of Central Java. This region, which includes the areas of Brebes, Slawi, Tegal, and Pemalang (Bergasmalang), is experiencing significant growth. The Port of Tegal serves as a crucial stopover for ships traveling from various parts of the archipelago or abroad en route to the ports of Semarang or Cirebon (State Gazette of the Central Java Provincial Government 2014). The researchers are motivated to explore the bilge water content on board vessels that rely on these ports. They aim to analyze the bilge water content before it undergoes processing using Oil Water Separators (OWS). After OWS treatment, laboratory testing and analytical methods will be employed to assess the oil/fat content in the bilge water.

Table 1: General conditions of Tugboat ships at Port of Tanjung Emas, Semarang.

Description	Tugboat Ship
Gross Weight (DWt)	< 10.000
Total Length (Loa)-(m)	120-142
Width (B)-(m)	20-22.43
Full Draft (m)	7.00-8.00
Length requirements standard	160-187
Container capacity (TEUs)	300

Source: Christino (2019)

The research data will be supported by variables such as pH, salinity, temperature, and other relevant factors. Considering these variables, the research findings will represent the actual conditions in the ports of Semarang and Tegal.

MATERIALS AND METHODS

This research is quantitative with a correlational method using statistical methods to measure the effect of different variables (Creswell 2014). The research was conducted in 2 ports, namely KSOP IV Tegal and Port of Tanjung Mas Semarang, with a total sample of 5 ships, they are the Semar Sebelas 88 ship, Tugboat Irving, Tugboat Roswin, Tugboat Bima 306, and Tugboat Jaya Negara 305 with taking sample on each ship, two treatments before and after processing using OWS, then it will be tested to determine the correlation between the pre-treatment and OWS pre-treatment variables. The sample is adjusted to the Indonesian National Standard SNI 6989.59:2008 concerning water and waste sampling (This study is included in the Laboratory Experimental category because the pre-test and post-test testing of 2 control groups have different treatments (Kuntjojo 2009) with the type of experimental research intact-Group Comparison Design, i.e., the study is divided into two groups, the control group is not given treatment, and the experimental group given the treatment (Setyanto 2005).

Research Stages

The research consisted of the preparatory stage in determining the ship sample according to the provisions of the ship size (tonnage), having an oil-containing water settling tank (bilge), and having a means of protection against oil (OWS). The second stage was to take two bilge samples from each ship before and after entering OWS; the third stage was testing with additional variables, i.e., pH, temperature, and TDS, using a pH and TDS meter. Then the samples were put into an ice box to be preserved naturally and then tested for oil/fat content in the laboratory using an FTIR (Fourier Transform Infrared Spectroscopy) instrument to determine the infrared emission spectrum of a simple substance in water containing oil. Then, the results of the data were analyzed and tested for the hypothesis using the SPSS application with the stages of analyzing descriptive data, validity, and reliability to find out the data was normally distributed. The F test was to see the suitability of the analysis model, and the regression test was to determine the effect between groups.

RESULTS AND DISCUSSION

The variable tests on ship samples are adjusted to research needs which aim to find the pre-post treatment samples using a means of protection against oil-containing water on board; the variables tested are total dissolved solids (TDS), liquid temperature, water acidity (pH) and oil content. The main function of an OWS (Oil Water Separator) system is to separate two liquids with different viscosities, such as water and oil. These liquids have distinct specific gravities, with oil typically having a specific gravity of 1 $mg.L^{-1}$ and viscosity of 0.89 cst. The difference in specific gravity prevents oil and water from being dissolved or mixed together. In the OWS, the oil will be filtered and separated by the coalescer filter so that the oil sticks to the filter and cleans the water. Before water is discharged into the sea, it goes through an oil content detection sensor connected to a monitor, commonly known as an oily discharge monitoring system. This sensor can detect oil content in the water, ensuring it is below the acceptable limit of 15 ppm. The water mixed with oil whose content is detected to be less than 15 ppm automatically flows and is wasted overboard, while liquids that did not meet the requirements because they were more than 15 ppm are returned to the OWS tank for further separation (Nwokedi 2020). The sampling from commercial vessels at Semarang and Tegal ports met the ship's criteria, particularly as shown in Table 2.

After direct conducting and laboratory testing according to the testing variables, the data were obtained as shown in Table 3.

pH (Degrees of Acidity)

pH is the negative logarithm of the concentration of hydrogen ions released in a liquid and is an indicator of the good and bad of water (Hamuna 2018). Because pH is essential for aquatic ecosystems, the biota can develop well when influenced by a standard pH value so that increased productivity, such as plankton, phytoplankton, and other biotas, because the availability of nutrients in the waters is sufficient (Megawati et al. 2014) based on the Decree of the Minister of the Environment No. 51 in 2004, the normal pH of seawater ranges from 6.5-8.5, so the results of pH measurements both in group I and group II were still within normal limits, at least 7.2°C I, it is the Bima 306 ship and the highest in group II, 7.1°C, it is the Semar Eleven 88, Irving and Jaya Negara 305 ships.

Water Temperature

Water temperature influences aquatic organisms' metabolism in waters and the distribution of water (Nontji 2005); temperature also affects the growth and life of biota and plays a role in controlling ecosystem conditions. On the surface also affects physical, biological, and chemical processes in sea waters (Kusumaningtyas et al. 2014). Nontji (2005) states that waters have average surface temperatures ranging from 28-31°C. The temperature measurements of ship samples in

Table 2: The particulars of sample vessels from Semarang Port and Tegal Port.

Name of Ship	Years of build	Gross Tonnage (GT)	Type OWS	Hours of power	Position of ship's
TB Bima 306	2009	294	PROTO HRS	-	Semarang
Jaya Negara 305	2018	350	PROTO HRS	-	Semarang
TB. Irving	2010	217	CYF-0,25	Mitsubishi 2 x 823 HP	Tegal
Semar Sebelas 88	2006	231	CYF-0,25	Yanmar 2 x 829 HP	Tegal
Roswin	2017	2230	CYF-J1 Electrical Controller	Yanmar 2 x 837 HP	Tegal

Source: Data Analysis in 2021.

Table 3: The Results of measurement and analysis of oil-containing vessel water (Bilge)

Name of Ship	pH water sample		Water temperature sample		TDS water sample		Oil/Fat Content	
	Grp. I	Grp. II	Grp. I	Grp. II	Grp. I	Grp. II	Grp. I	Grp. II
Semar Sebelas 88	7.5	7.1	27	28	32.5	14.5	4.515	25.27
TB Irving	7.8	7.1	27.6	28	48.5	27.3	71.84	52.27
TB Roswin	7.6	7	28	29	48.7	30.0	3.436	46.01
TB Bima 306	7.2	7	26.8	28	36.2	22.6	4.687	41.65
TB Jaya Negara 305	7.4	7.1	27	28	36.7	23.3	7.196	52.00

- According to KM for Environment No. 51 in 2004 concerning quality standards for variable seawater, the maximum oil/fat content is 5 $mg.L^{-1}$.
- Natural temperature variable
- The pH variable is 6.5-8.5
- TDS is 80
- Group I before being processed by OWS and Group II after being processed by OWS

Table 4: Results of SPSS regression.

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	1133.393	1	1133.393	65.841	0.000[a]
Residual	309.852	18	17.214		
Total	1443.245	19			

a. Predictors: (Constant), Kelompok_1
b. Dependant Variable: Kelompok_2
Data Analysis: 2021

group I and group II are still within normal limits, at least 27°C in group I, the Semar Eleven 88 and Jaya Negara 305 ships, and the highest in group II, which is 29°C in Roswin ship.

TDS (Total Dissolved Solids)

TDS has dissolved solids in a liquid, showing that the liquid contains salinity/saltwater content because TDS is related to salinity (Nurrohim 2012). From the data, it was found that the highest TDS content was in Group I on the TB Roswin ship, and the lowest TDS content was in Group I on the Semar March 88 ship. In group II, the highest TDS was on TB Roswin. The lowest TDS was on the Sebelas Maret 88 ship. However, it can be concluded that the TDS content in Group I and Group II had significant changes resulting in a decrease after going through the separation process at OWS.

Oil Content

Oil has different characteristics from other liquid contents (Hardian 2014); oil content can form a thin layer and float on the surface of the water. In Marine Pollution 1978 (MARPOL 73/78), in annex I, it is explained that every ship that has a GT of more than 100 GT or has a minimum propulsion power of 200 HP must have a means of protection against oil/fat content because oil pollution from ships is quite dangerous for marine ecosystems. The oil/ fat content in group I and group II experienced significant differences in testing using FTIR/Fourier Transform Infrared Spectroscopy which was tested at the Center for Industrial Pollution Prevention Technology (BBTPPI) Semarang. FTIR is a laboratory testing process to find out the infrared spectrum in absorbing the emission of a substance. Its function is to detect liquid functional group compounds and analyze the mixture in the sample being analyzed, both qualitatively and quantitatively identified, so that the valid value is known in the sample.

Regression Data Analysis

Regression analysis aims to determine whether there is a binding relationship between Group I (before processing at OWS) and Group II (after processing at OWS). Regression test by comparing data on temperature, pH, TDS, and oil content in group I to group II there is an effect.

Significant research data (0.000 <0.05) means Ho is rejected (Table 4). In other words, Group I and Group II have a significant effect. From this data, it was stated that after processing at OWS, there were significant differences in data between Group I and Group II.

Significant research data (0.000 <0.05) means Ho is rejected in both Group I and Group II. The data suggests there were significant differences in data between Group I and Group II after undergoing processing in the OWS system.

CONCLUSION

A sample of water was taken from two out of five vessels for analysis. The first sample was collected before being processed by an Oily Water Separator (OWS), while the second sample was taken after being processed by an OWS, as guided by the Minister of Transportation Regulation No. 4 of 2005. According to this regulation, oil ships ranging from 100 to 149 GT and other non-oil ships between 100 and 339 GT, equipped with a 200 PK or main engine, must have oil protection devices installed. Unfortunately, not all ships in Indonesia are adhering to these regulations properly. Many motorized sailing ships, for instance, do not have OWS installed. Additionally, several commercial ships have OWS, but their crew fails to process bilge liquid according to the required conditions.

The sampling test results showed that the variables Temperature, pH, Total Dissolved Solids (TDS), and oil content obtained values below the threshold for water quality standards set by the Decree of the Minister of Environment No. 51 in 2004, which defines water quality standards. After the hypothesis testing, there was a significant and intertwined relationship between the variables, as the Ho results were rejected because the value reached 0.000.

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