A Study of Oil Spill at Marine Companies: Factors and Effects

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Abstract Shipping activity is growing rapidly due to the effectiveness of marine transports in fulfilling the high demand of a global trade. The oil spill in the ocean is a serious issue due to its adverse effects, especially in the marine environment and the economy of the country. The oil pollution was caused by several factors, including human error, negligence, technical error, equipment failure, system failure, failure in implementation of required safety procedures, incompetency of crews and natural disaster. The aim of this research is to identify the main factor contributing to the oil spill as a preliminary study to prevent an unnecessary oil spill incident. Questionnaires survey was conducted on staff of oil and gas company and a maritime government agency in Lumut, Perak, Malaysia. The result shows the most significant factor of the oil spill is from human error which is resulted from in compliance of the standard operating procedure such as lack of technical skill (ship handling, operating system), communication failure between staff, fatigue and poor to follow rules and regulation at work place. Meanwhile the second part of this research is to identify which of these three factors of independent variables can be assumed as the most effect variables towards the dependent variables (environmental and economic) by measuring the strength and relationship between the variables. The result indicates natural disaster the highest positive relationship ($r = 0.778$) towards environmental effect and, human error indicates the strongest relationship ($r = 0.660$) for economic factors that effect to the oil spill.

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1 Introduction

The shipping industry is the earliest industry in the world with a diversification of exchange of goods of an international trade. Sea transport is a cheap transport cost as compared to transport by air as collectively states by Luoma [35], Chang et al. [9], but the sea transport also has a great risk especially in the event of an oil spill. Some countries depend on oil production and trade in generating national income. The hydrocarbon spill in the marine environment is very dangerous to the marine life, affects the human health, and bring down the economy of a country as state by Teal and Howarth [55], Aguilera et al. [3] and Fingas [20]. Water resources will be tainted, and contamination of the soil and the operating beach and port industry will be delayed because of the oil spill, as the industries require clean sea water supply to resume operation. The biggest catastrophic threat to the sea is the issue of the oil spill and the release of harmful chemicals into the sea. Malaysia is a member of several international conventions concern on marine pollution such as United Nations Convention on the Law of the Sea (UNCLOS) 1972 [56] and International Convention for the Prevention of Pollution from Ship (MARPOL) 1973/78 [36]. Annex 1 of the MARPOL specifically mentions on the prevention of pollution by oil at sea.

This research focuses to analyze the most significant factor contributes to the oil spill and, to determine the effects of the oil spill. This research was conducted at three different organizations which are; oil & gas company, maritime operator organization, and maritime government agency. The selected oil and gas company involves in providing maintenance and repairing the floating oil and gas facilities, piping the oil and gas pipes, as well as the construction of platforms offshore. The maritime operator organization involves in providing a transportation service to passengers. Meanwhile, the maritime government agency is establishing to monitor and manage all matters relating to port, shipping activities, responsible in ensuring the sailing ships sail safely, conducting inspection on vessels on license, ship identification and compliance of regulations, monitoring, providing an assistance to ships and responsible for supervising the seafarers' examination.

2 Methodology

2.1 Theoretical Framework

A theoretical framework is a structure supports a theory of the research and is used to determine the relationship of the study. An independent variable is a variable change in a scientific experiment to study on the effect of the dependent variables.

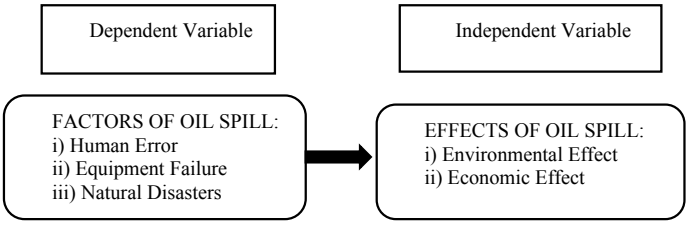

Fig. 1 The research theoretical framework

The dependent variable is the variable which measures in a scientific experiment as mention by Hogreve et al. [28]. The independent variable focuses on the element of factors of an oil spill such as; human error, equipment failure and natural disaster. The human error has collectively state by Chauvin et al. [11]. Chicago: National Safety Council (2008), Rothblum [48], Anderson and LaBelle [7], Kontovas et al. [30], Gasparotti [22] and Abdulrazaq and Kader [1]. Meanwhile, for the equipment failure supports by Okoye and Okunrobo [41], Okechukwu Anyanwu [41], Lee et al. [32], Akpomuvie [6], Omofonmwan and Odia [42], and for natural disaster has agree by Sholeye et al. [52], Akpofure et al. [5], Hogarth [27], Pine [46], Cruz and Krausmann [14], Grimaldi et al. [25] and Wang et al. [58]. On the other hand, the elements in the dependent variables are environmental and economic effects. The environmental effect has support by Teal and Howarth [55], Aguilera et al. [3] and Fingas [20], Farrington [19], Siliman et al. [53], Sumaila et al. [54], Corn [13], Demopoulos and Strom [17], Ajide and Isaac [4], Adelana et al. [2], Ordinioha and Brisibe [44], Barry [8], EPA [18], Klemas [29], DeLeo et al. [16], Sagerup et al. [50], Shigenaka [51] and Giri et al. [24]. Finally, for the economic effect has collectively agree by Montewka et al. [37], Zock et al. [62], Verma [57], Hayworth et al. [26], Opukri and Ibaba [43], National Commission [39], Gill et al. [23], Barry [8], Opukri and Ibaba [43] and Ajide and Isaac [4] (Fig. 1).

2.2 Population, Sample and Respondents

The population of this research involves employees in the oil and gas company, maritime operator organization, and maritime government agency. The 92 sample is taken at 40% of the total population. 65 respondents participated as shown in Table 1, and the response rate is at 70.65%.

Design of Questionnaire. The questionnaire consists of five sections which are; Section A: Respondent's background, Section B: Company's Background, Section C: Factors to oil spills, Section D: Effects of the oil spill and, Section D: Suggestion and Opinion from respondents.

Table 1 Population, sample and respondents

Breakdown	Population	Sample	Respondents
Oil and gas company	140	42	30
Maritime operator organization	40	20	15
Maritime government agency	50	30	20
Total	230	92	65

3 Results Analysis

This section discusses three main analysis which are demographic analysis, factor analysis and regression analysis. The demography analysis is a statistical and mathematical analysis use to study respondents' size, composition, distribution of human populations and, how these features change over time. Data are obtained from the record of the events such as gender, age, marital status, educational background and working experiences as state by Lawrence [31], Neubert and Caswell [40], Xie [61] and Li [34]. In addition, descriptive statistic is a summarize table from the research result and reflect population, sample, respondents, and the data has split into mode, mean, median, standard deviation and variance. It is applied to compress and summarizes the data clearly for report preparation as mention by Data [15], Runyon [49], Wiersma [59] and Leech [33]. Moreover, a regression analysis is used as it is one of the most widely used technique for analysing multifactor data and, is apply to express the relationship between a variable of interest (the response) and a set of related predictor variables as agree by Pedhazur [45], Fox [21], Montgomery [38] and Chatterjee [10].

3.1 Demographic Analysis

Demographic study shows the background data from each 65 respondents that randomly selected for this survey. This analysis is important to learn more about a sample characteristic to determine the suitability of their response towards this survey and further explain the result. Table 2 shows list of selected respondents' background, such as gender, age, highest education and working experiences. This selected background is according to their relevancy towards oil spill factor and effects. From 65 respondents, there are 50 male and 15 female respondents. There is a difference in gender as the oil and gas company, maritime government agency and maritime operator organization are involved in a heavy engineering industry, which requires more male manpower in general, and female staff involve in administrative matters. The range of the age is between five years, which refer to the age range of the staff of the selected companies. The group of the age is considering several factors such as their position and working experiences. In the age range between 31 and 35 years

Table 2 Respondents demography results

Descriptions	Results	Percentage
Gender	Frequency	
Male	50	76.9
Female	15	23.1
Age	Frequency	Percentage
20–25 years	4	6.2
26–30 years	11	16.9
31–35 years	32	49.2
36–40 years	18	27.7
Marital status	Frequency	Percentage
Single	24	36.9
Married	35	53.8
Divorce	6	9.2
Highest education	Frequency	Percentage
SPM/PMR	1	1.5
Diploma	5	7.7
Degree	26	40.0
Master	33	50.8
Working experiences	Frequency	Percentage
Less 5 years	29	44.6
5.1–10 years	12	18.5
10.1–15 years	19	29.2
15.1–20 years	3	4.6
20.1–25 years	2	3.1

old, shows the highest feedback which is at 49.2%, and followed by the age range between 36 and 40 is at 27.7%. This value is enough to represent age range for all the samples as a majority. The majority staff who is included in this age are holding positions from middle management to top management and, it is related to the position and experience to counter the issue towards the factor and effects of oil spill. In terms of marital status, the majority are married which is at 53.8%. There is not much difference for the academic qualification among respondents for Bachelor holding is at 40.0 and 50.8% for Masters. Only 7.7% respondents holding Diploma. In the scope of the research required at least staff with Diploma to carry marine operation daily tasks at ports. Besides that, this research shows that most of the respondents with working experiences are less than 5 years at 44.6%. The working experiences staff who are especially involved in marine operation are eligible to the organization due in covering issues in the oil spill. It is because experiences staff is highly knowledgeable and manageable to handle big incidents and the employers have taken an

Table 3 Descriptive statistic

Factor	Results			
	N	Mean	Std. Deviation	Std. Error mean
Human error	65	4.0484	0.34835	0.04321
Equipment failure	65	3.8879	0.37669	0.04672
Natural Disaster	65	3.8484	0.41717	0.05174

appropriate decision in recruiting them and placed at the relevant working experiences in combating the oil spill issue. The duration of more than 5 years to 15 working experiences are enough to measure the capability of their work and this is supported by Wiesenfeld et al. [60] states that, experiences workers gaining a lot of experiences on working situation and meet the standard quality of work parallel with the salary gained.

3.2 Descriptive Statistics (Factors)

There are three main selected factors that contribute to oil spill at selected marine company which are human error, equipment failure and natural disaster. These factors can be simply measured using descriptive statistics. The analysis in Table 3 shows the descriptive statistics for all the variables in the research. Typically, the mean, standard deviation and number of respondents (N) who participated in the research are given. Looking at the mean, conclude that the factor of human error is the most important variable that influences and contribute to oil spill at marine company as agreed by respondents and it has the highest mean of 4.05. This is supports by Rothblum [48], claim that 80% of oil tanker accidents that lead to oil spill are from the human activities and errors. Based on the survey to the respondents, most common sub-factors are significant and represented to the human error are; lack of technical skill (ship handling, operating system), communication failure between staff, fatigue and poor to follow rules and regulation at work place.

3.3 Correlation (Effect)

From this analysis, the relationship between independent variables and dependents variables are evaluates. In this section, contain two results of correlation between independent variables with two variables of dependent variables which are environmental effect and economy effect respectively. Ideally, the aim for the second part of this research is to identify which of these three factors of independent variables can be assumed as mostly effected to the oil spill by measuring the strength and

relationship between the variables either tend to increase and decrease the direction of the lines.

Correlation Effect on Environmental. The reason for the environmental and economic are chosen as the dependent variables due to the collective severe effects on ecosystems and the environmental where the oil spill is released, it is also involve oil toxic effect on the habitats, seafood, marine mammals, plankton, coral and marine habitat by Siliman et al. (2012), effect ocean and bring the marine life to extinction either quickly or slowly by Farrington [19], takes a long time to restore oil spill as affects habitat, mangroves, food chain structure in the area by Sumaila et al. [54], effect flora and fauna on the seafloor, fish that eat plants on the seafloor are also affected by the inundation of plants that are stuck with oil by Corn [13], Demopoulos and Strom [17], effect people near oil spills and cause their crops to be damaged due to mixing with the spill oil and underground contaminated water by Ajide and Isaac [4], Adelana et al. [2], effect the reduction of nutrients and proteins in foods such as vegetables, cassava, and fish which are mixed with toxic oils and can harm humans and animals by Ordinioha and Brisibe [44] and Verma [57], effect life and health of the people in the immediate area of the oil spill by Barry [8], Ordinioha and Brisibe [44], effect on respiratory problems, skin inflammation, difficult to get clean food and water by Adelana et al. [2] and Zock et al. [62], effect DNA damage which can cause cancer and multigenerational birth defects by EPA [18], effect the marine life by DeLeo et al. [16], Sagerup et al. [50] and, effect wetland and estuarine habitat by Klemas [29].

Correlation Effect on Economic. In addition, the process of cleaning up the oil spill require quite a while and the cost is expensive. The oil spill causes the coastal areas to be contaminated and disrupted the recreational activities such as camping, fishing, and swimming. The cleaning up is expensive and need to consider the types of oil spill, quantity spill, size of the spill, spill distance of the oil with the coast by Montewka et al. [37]. It effects income to decline and causing rural population move to the urban area to find additional sources of income in sustaining life, affects the tourist activities and cause the number of tourists to decrease by Hayworth et al. [26], effect the closure of the fishery sector and causing fishermen to lose the source of income by National Commission [39]. The tourism industry that rely on the water activities such as skating, kayaking, swimming, and rafting are also affected and cause the hotels, restaurant owners, tenant boats, dive tour operators and others who have income from the recreational activities in the coastal zone will experience a significant economic loss by Gill et al. [23]. The activities such as farming, agriculture, and fishing will be affected and forced into unemployed or to change to another jobs for survival by Barry [8], Opukri and Ibaba [43] and effect economics and human health through the contamination and death of fishes by Ajide and Isaac [4].

Correlation analysis describe the strength of the relationship between two or more variables based on Table 4. Pearson correlation coefficient (r) is a measure to determine the strength of the alliance between the two variables as propose by Coakes et al. [12] and, two variables are related to each other then, the variables are

Table 4 Range of values for the correlation coefficient

Correlation coefficient	(r)
Perfect negative	−1
No correlation	0.00
Very weak	0.00 to 0.19–0.00 to 0.19
Weak	0.20 to 0.39–0.20 to 0.39
Moderate	0.40 to 0.59–0.40 to 0.59
Strong	0.60 to 0.79–0.60 to 0.79
Very strong	0.80 to 1.0–0.80 to 1.0

said to be correlated as a claim by Puth et al. [47]. This analysis helps to derive the degree and the direction of such relationships both variables.

Tables 5 and 6 indicates the result of relationship between independent variables (human error, equipment failure and natural disaster) with dependent variables (environmental and economy). Ideally, this analysis is conducted to identify which one of the factor mostly effect towards the oil spill by measuring the strength of the coefficients. According to Table 5, it shows a strong association between all three independents (factors) variables with dependents variable (environmental) with the range of coefficient r = 0.683 to r = 0.778. The result shows that natural disaster indicates the highest correlation coefficient that gives positive and strong relationship with environmental effect (r = 0.778) as the natural disasters are a natural event, and is out of human influence which cause phenomena such as earthquakes, hurricanes, adverse weather conditions as collectively claim by Sholeye et al. [52], Ajide and Isaac [4], Adelana et al. [2], Ordinioha and Brisibe [44] and Verma [57].

Meanwhile, the second result from Table 6, shows a strong association between only two independents (factors) variables with dependents variable (economic) with the range of coefficient r = 0.642 to r = 0.660 which are human error shows the highest coefficient correlation value (r = 0.660). It is true that the human error factor

Table 5 Correlation independents variables and environmental effect

Pearson correlation (Sig. 2-tailed = 0.000, N = 65)	
	Environmental effect
Human error	0.694**
Equipment failure	0.683**
Natural disaster	0.778**

Table 6 Correlation independents variables and economy effect

Pearson correlation (Sig. 2-tailed = 0.000–0.002, N = 65)	
	Economy effect
Human error	0.660**
Equipment failure	0.378**
Natural disaster	0.642**

in contributing to the oil spill leads to economic efficiency. This is because the people nearby area of the oil spill tends to lose income from affected fish with the mixing chemical from the oil spills and the cost to clean up the spill oil is expensive as collectively agree by Akpofure [5], Opukri and Ibaba [43], Gill et al. [23], Montewka et al. [37] and Ajide and Isaac [4].

4 Conclusion and Recommendation

As a conclusion for the first objective, it was found out that human error is the main factor of the oil spill as agree by Abdulrazaq and Kader [1], Chauvin et al. [11], Adelana et al. [2] and Rothblum [48]. Meanwhile, the conclusion for the second objective is that most of the independent variables have a strong relationship with the dependent variables. Human error, equipment failure, and natural disaster have a strong relationship towards the environmental and economic effect. The presence of the oil spill in the environment contributes significantly to the degradation of the environment and affects the economy of that area. It is undoubtedly that the oil spill is a serious issue, which can lead to the destruction of nature and the organism, whether it is immediate or long-term as agreed by Verma [57], Farrington [19], and Ordinioha and Brisibe [44].

As a recommendation, an efficient cleanup and remediation programs need to be conducted as the oil remains in the water. The human error can be reduced if one takes an extreme precaution and proper safety assessments. The related authorities such as Department of Environment (DOE) and Marine Department (MARDEP) need to ensure the person handling vessels or jobs related to carrying oil in the sea, especially oil tankers, must have a valid certificate, not under the influence of alcohol and prohibit the use of illegal drugs. In minimizing the pollution of the oil spill by human error to the marine environment, the workers or crews need an adequate and enough series of training. Secondly, the rule on double hull requirement needs to be complied with by tanker ships. Double layers of a watertight hull surface are a precaution in minimizing the pollution, which normally occurred during a collision, grounding or any other unexpected accident. Finally, sea pollution due to oil spills can also be reduced by using environment-friendly technology, by replacing the petroleum power to a solar power consumption.

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