

Assessment of Oil Spill Damage to Marine Ecosystems: Some Foreign Experiences and Conditions to Be Applied in Vietnam

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Abstract— Currently, oil pollution at sea is one of the serious marine pollution issues that are of great concern to the international community. The incidents of oil exploitation and transportation in the world have become a great threat to the environment in general and ecosystems in particular. Many oil spills have occurred with serious long-term consequences for the ecological environment. Oil pollution in the East Sea in general and oil pollution in the Vietnam Sea in particular are not out of that situation. Marine ecosystems are one of the most important resources for Vietnam's development. However, in recent years, the marine ecosystem has been subject to many negative impacts from the environment, especially the risk of pollution caused by the oil spill when Vietnam is a country with large oil exploitation and import and export activities. In fact, evaluation methods have been widely applied to accurately identify losses. These losses will be an important basis to make decisions to sanction pollution acts. It is also the forecast information channel for ministries and agencies in development planning and devising strategies to minimize losses from the oil spill.

Keywords— Oil pollution, oil spill, marine ecosystems, Vietnam.

I. INTRODUCTION

Since the mankind has been known to exploit and use oil until now, incidents in the exploitation and transportation of oil in the world have become a great threat to the environment in general and the ecosystem sea in particular. Environmentalists estimate that from 1900 to the present, an average of 2 to 4 major oil spills in the world each year. Notable incidents include: in 1978, the Amoco Cadiz vessel poured 231000 tons of crude oil into Brittany, Northwestern France; in 1989, the Exxon Valdez spilled 40,000 tons of oil off Alaska (USA); in 2002, the Prestige ship spilled 77,000 tons of oil off the northwestern coast of Spain; In 2007, the Hebei Spirit ship spilled 2.7 million gallons of oil into the southwestern sea of Korea[1]. Most of the oil spills at sea are serious environmental catastrophes accompanied by huge economic losses[2].

In the history of the world, many horrific oil spills have occurred, which not only affects the ecological environment but also a great damage to the regional national economy.

It is impossible not to mention the oil spill that caused the whole US headache in 2010 in the Gulf of Mexico, the Deepwater Horizon oil rig, off the coast of Louisiana - the Gulf of Mexico suddenly exploded and sank, causing at least 11 workers to suffer damage, causing the most serious oil spill in the US in about half a century[3].

Millions of gallons of oil spilling into the sea threaten the ecology of the region that has been hit by floods and storms.

This is also the largest oil spill in history.

During the 1991 Gulf War, when Iraqi troops withdrew from Kuwait, they opened all valves of oil wells and broke oil pipelines to halt the advance of US troops. As a result, the largest amount of oil in history has covered the Persian Gulf[4]. It is estimated that the amount of oil slicks is equivalent to 240 million gallons of crude oil. Oil spill area is about the size of Hawaii[5].

To protect the water from contamination, they had to mobilize about 40 km of floating oil suction rods and 21 oil separators from the water. Together with the series of oil-suction cars, they collected 58.8 million gallons of oil[6].

Before that, the history of the world has also witnessed many terrible oil spills, which were influenced first by the environment and marine ecosystems.

Experts assess that the concentration of oil in water of 0.1mg / l can kill phytoplankton, greatly affecting the juveniles and larvae of benthic organisms, oil adhesion to the body or autoclave. consumption through water filtration reduces the use value[7].

Oil contaminates microorganisms. Small fish eat microorganisms, and big fish eat small fish. Seals, dolphins, whales, birds ... and people eat fish. All poisoned.

Oil polluting the environment causes mass deaths of fish due to lack of dissolved oxygen in water; oil attached to fish reduces use value due to unpleasant odor; Oil can cause the egg to lose its ability to grow, and the eggs may become cancerous or rotten[8].

As a country with relatively large oil exploitation and import and export activities, Vietnam is inevitably facing the risk of pollution due to oil spills. International conference "Exchange of experiences in the development, response, handling and remediation of oil spill pollution at sea" by the Ministry of Natural Resources and Environment on February 28, 2018 in Hanoi, since 2002 Vietnam has experienced 105 oil spills, causing great ecological and economic losses; Of which, up to 77% of oil spills in our country's waters but have not been compensated or in the process of settlement. A fundamental reason for this situation is that the specialized management agencies in our country lack the legal basis to handle the case. Moreover, many losses can be avoided or reduced if future development planning takes into account the causes of environmental losses[9].

Oil spills often impact the environment on a large scale. The objects affected are quite diverse and under the complicated mechanism, long term. Many physical losses can be determined by visual means; while, many other losses

cannot be identified with these tools. Up to now, world environmental economists have successfully built many different methods to be able to reliably assess the total losses caused by the oil spill[10].

However, such evaluation information is not sufficient to meet the requirements of State management of the environment. Requesting a decision to sanction an environmental polluting act cannot wait for long-term scientific research to fully measure the consequences of each case. Moreover, development planning and strategies to minimize losses from natural disasters and environmental degradation require predictive information[10]. From the results of the actual incident losses, it is calculated that the impact factors serve as a basis for quickly estimating the economic losses of the incident or to forecast for hypothetical situations.

Stemming from that practice, this article would mention three contents: (i) The theory of environmental evaluation, ecosystem of the sea; (ii) Some basic methods of assessing oil spill losses and applicability in Vietnam; (iii) The scientific basis of the method of rapid evaluation for the forecast, management of the State, handling and deciding on compensation for damage to oil spills.

II. OUTLINE THEORETICAL EVALUATION OF ENVIRONMENT AND MARINE ECOSYSTEMS

A. The total value of marine ecosystem

To avoid omission or duplication, the economic value of the marine ecosystem is calculated by the method of total economic value, including the values used and the values not used.

Usage values can be regarded as values formed from direct and indirect use of natural resources, including:

- Direct use value: The goods and services provided by the environment can be directly consumed such as firewood, construction materials, seafood, oil, tourism, transportation[11].
- Indirect use value: Benefits from the ecological environment such as CO₂ absorption, climate control, flood and storm prevention, wildlife residence, biodiversity.
- Unused values may be benefits that will be exploited and used in the future or cultural and spiritual values, including:
 - Transmission value: Potential values that are not used in the present but can be used in the future such as: minerals, chemicals, entertainment, new pharmaceuticals ...
 - Existence value: Truly meaningful values such as culture, aesthetics and heritage play a role in cultivating pride and good feelings for many generations.

In general, the total economic value of marine ecosystems can be considered as shown in Figure 1: The above classification aims to simplify the system of value arrays, but in reality there is no completely clear boundary between these areas because many factors may contain different values.

B. Impact of oil spill on environment and marine ecosystems

Crude oil is a mixture of substances that are liquid, viscous, insoluble in water and lighter than water. When slipping on the surface of the water, the oil forms a sticky, hard-to-wash, and difficult to evaporate; May contain toxic

compounds before and after decomposition. With the physicochemical properties mentioned above, oil spill acts directly or indirectly on the coastal and coastal ecosystems in the following ways: Firstly, to change the oxygen balance of the ecosystem, prevent oxygen exchange between water and The atmosphere, facilitating the accumulation of toxic gases such as H₂S, and CH₄, increases the pH in the environment. Second, the oil penetrates and disturbs the living activities of the organism. Oil interferes with the osmotic pressure between the biofilm membrane and the environment; Losing the ability to regulate the pressure in the body, losing the waterproof ability of feathers and marine animals[13]. Thirdly, oil causes potential toxicity in the ecosystem when decomposed, deposited and accumulates in the sedimentary layers of the ecosystem.

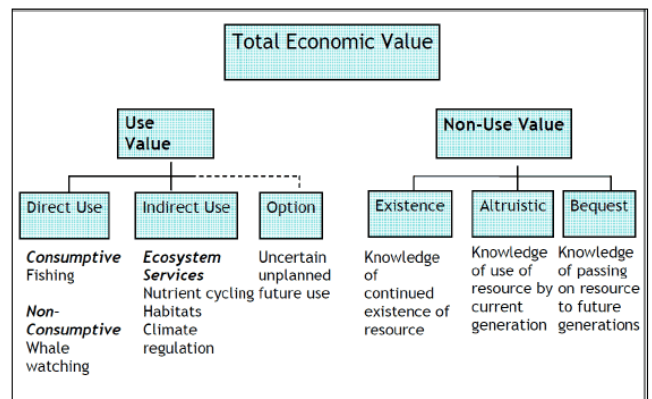


Fig. 1. The total economic value of marine ecosystems[12]

Direct impact

Oil pollutes the environment causing fish and many marine creatures to die in large numbers due to lack of dissolved oxygen in water. Oil can cause acne, rottenness, reduced ability to develop young and the number of species. For commercial seafood, the oil may adhere to or absorb into the organism through the water filtration process, leading to a reduction in usage value due to the smell of the oil[14].

Oil slicks on the organism, which will prevent the respiration, metabolism and movement of organisms in the aquatic environment. The effect of oil on seabirds is mainly is to wet the feathers of the bird, reducing the insulation of the plumage, losing the heat protection effect of the bird and swimming function. The same risk applies to marine mammals such as sea otters, bears and arctic foxes[15].

Spill oil also reduces the value of beaches in tourism activities, directly causing economic losses due to investment in responding to and handling the consequences of oil spills; polluting and affecting the community's health based on marine ecosystem; reduce productivity and quality of aquaculture in coastal areas; depleting the resources of living organisms in the ecosystems that are exploited daily[16].

Indirect impact

When damaging plankton, the oil affects the first link in the ocean's food web, indirectly affecting other species in the chain, causing production decline and imbalance in future species, declining habitats of species living in ecosystems. The effects are due to oil seepage in the soil, sand, groundwater

and the impact on adjacent fishing grounds due to the impact from seed sources and related nutrition. By causing damage to corals, sea grass, mangroves, oil spill indirectly causes coastal erosion and reduces the wave break environment. Oil spill also prevents people's activities, reducing people's income by affecting health, reducing landscape and ecological values and reducing income from tourism as well as related services[17].

Oil spills also cause damage to stored values such as affecting natural resources, landscapes, etc. Oil spills gradually lose conservation values like rare plant species as raw materials, precious herbs, rare and precious genetic resources, habitats of some marine creatures, natural resources left for future generations (corals, seagrass ...). The incident also gradually diminishes the value of the ecosystems of the ecosystems, which come from a sense of resource retention based on faith, pride and intangible values related to cultural and spiritual life, etc., losing resources for scientific research, education, aesthetics and culture[18].

As such, the spill has a direct and indirect impact on the usage and unused values. The quantification of values used is complex but quite intuitive. The contentious issue is the quantification of the loss of unused values. Many people understand that factors such as rare genomes and undiscovered pharmaceutical resources will be valued depending on the level of human awareness. Therefore, some people believe that the evaluation is not possible or deviates greatly from the real value. In order to avoid such conflicts, it is necessary to stipulate that: the assessment of losses is a scientifically determined total sum of losses attributable to environmental losses and ecosystems based on current level of awareness. there's humanity's[2].

III. SEVERAL METHODS OF ESTIMATING LOSSES DUE TO OIL SPILLS AT SEA AND THE POSSIBILITY OF APPLICATION IN VIETNAM

A. Group of methods for estimating environmental losses

The evaluation of environmental value and the assessment of losses due to pollution and environmental degradation basically use the same assessment techniques, collectively called environmental assessment methods. Differences in environmental values before and after an incident are considered as environmental losses caused by that incident.

There are many environmental assessment methods that have been studied and used. However, the classification that is considered to be simple and commonly used today is the classification of the World Bank

B. Some typical evaluation methods and applicability in Vietnam

So far, countries around the world have used a variety of techniques to determine the level of economic damage of the environment when an incident occurs, however, the selection of techniques and processes. Depending on the specific conditions of each country and each case; At the same time, it is strongly influenced by other factors such as database base, understanding of ecosystems and the time required to survey. Some of the most commonly used assessment methods in the world today and relate to the possibilities applicable in Vietnam as follows:

Market price method

Market price method is a method of determining the value of ecosystems through exchanging and trading of products and services of the ecosystem. Losses due to environmental incidents may be determined by changes in the quantity and quality of goods or services as a consequence of the incident. To apply this method, it is necessary to determine the production surplus and consumer surplus of goods and services before and after the oil spill. Production surpluses are estimated through production costs and the revenue received from goods that meet the market demand[19].

This method is simple, intuitive and easy to understand. Collecting data on market price, buying and selling volume is relatively simple and the cost is not high. To assess the impact of the oil spill in coastal areas of Vietnam, this method has many advantages because the collection of statistics, survey studies is quite diverse and detailed has been conducted by General Department of Statistics and many domestic and foreign organizations and individuals.

However, this method has some limitations such as: it is very difficult to distinguish the impact from incidents with other impact factors to avoid duplication and lack of loss value; it is impossible to measure losses that are not directly reflected in the market, which are unused values. Therefore, the market price method needs to be used in combination with other methods to be able to estimate the total value of losses.

Travel Cost Method – TCM

The travel cost method uses tourist expenses as a basis for calculating the value of attractions. By collecting the number of travel expense figures and other relevant factors (income, number of visits, etc.), it is possible to estimate the total amount of money that tourists are willing to pay. pay for specific environmental landscapes (2). This method is often applied to tourist areas, monuments with large numbers of visitors from different regions. The travel cost estimation method has three basic approaches: regional travel costs (ZTCM), individual travel costs (ITCM), and the random benefit approach (Random Utility) Approach). It should be noted that the first two approaches are more common and simpler, while the third is more complex and costly and is also the best approach to assess the benefits of specific locations[20].

This method is acceptable in theory and practice. This method is based on the traditional economic model, which is the practical relationship between the quality of environmental goods and the costs spent to enjoy the value of goods. This method is based on practical behavior so it is easy to understand and implement. Our country now has many tourist destinations with high value, beautiful landscapes ... Therefore, the selection of the method of tourism cost by region is highly feasible.

However, the major drawback of this method is that it is only used where there are many tourists. Therefore, places without or few tourists are not applicable. Moreover, even at popular tourist places, instead of visiting often, some buyers are always close to that location to stay. In many cases, the object does not have to spend money (indigenous people) but highly appreciates the quality of the environment there. As such, it is not possible to value the environment with only one

tourism cost method, which must be combined with other methods.

Productivity Change Method

The productivity change method focuses on natural resources as an input to the production of goods and services. When the input decreases, it will lead to a reduction in services provided to production, resulting in a reduction of producers' benefits at market prices. The total reduction in benefits is the damage caused by environmental incidents. This method is widely used in the field of environmental assessment; for example, assessment of losses due to: soil erosion, air pollution, acid rain, pollution to aquaculture environment, saline soils.

The use of these methods requires a database of yields, crop yields, livestock, aquatic and marine product exploitation in the study area just before and after an environmental incident. For localities that have recorded all of these data over time, it is relatively easy to assess the losses to the direct use value. As an agricultural country with existing data and farmers' in-depth knowledge about plants and animals; Productivity change methods can be conveniently applied in Vietnam.

However, as many of the evaluation methods stated, there are many factors that affect crop yields, livestock and production yields. Attention should be paid to the separation of the impact of environmental incidents from other impact factors and to account for the fluctuations in productivity over time. Using market prices may produce false results if it is not possible to separate administrative effects such as taxes, subsidies, protections or monopolies.

Cost of Illness

The health costing method is used to calculate the cost of curing diseases caused by environmental pollution. This cost is considered as the value of damage caused by the oil spill to human resources. In the health cost method, the damage is determined based on the relationship between pollution level and the level of impact on health. Research is based on the incidence of recurrent disease to measure the impact of abnormal events.

By measuring the variation in the number of people infected between periods and compared to the period of the incident, the impact of the incident can be determined. The evaluation also examines the extent of the impact of the disease relative to the total cost including medical services; cost of prevention, treatment and recovery. The direct cost is the value of resources instead of creating other goods or services, it is used to pay for medical services, which are costs for medicine, inpatient and outpatient treatment. accommodation, travel expenses from home to the medical center and waiting time. Indirect costs are a person's ability to work, the income of the patient is lost, the loss is interrupted during the period of labor replacement.

In general, the health cost method is easy to apply to assess environmental impacts when diseases are usually short, isolated, and have no negative effects in the long term. However, this method is difficult to deal with chronic diseases when the disease stage is prolonged. Health cost studies are often based on estimates, so there may be uncertainty and assumptions exist in determining the cost of disease. In order

to apply this method effectively, it is necessary to select suitable projects and programs according to a number of guidelines such as establishing an online relationship.

In rural areas and coastal areas of Vietnam, where socio-economic development is not strong, short-term and non-dangerous diseases are often of little interest, and people tend to let the disease go away on its own. or using some folk remedies, it is difficult to determine the cost of treatment. In addition, the toxins in oil spills when causing dangerous diseases often have large delays, difficult to detect early. Therefore, the application of the health cost method in Vietnam may face many limitations, difficult to bring accurate results.

IV. GENERAL ASSESSMENT OF SEVERAL METHODS FOR ESTIMATING LOSSES DUE TO AN OIL SPILL

Through the research and handling of oil spills in the world, the World Bank (WB) believes that oil spills in the sea often damage biodiversity and deplete marine ecosystems. It has a significant influence on the income and life of people in the region, and has a strong impact on human behavior. The feasible and effective pricing techniques for oil spill recommended by WB are summarized in the following Figure 2:

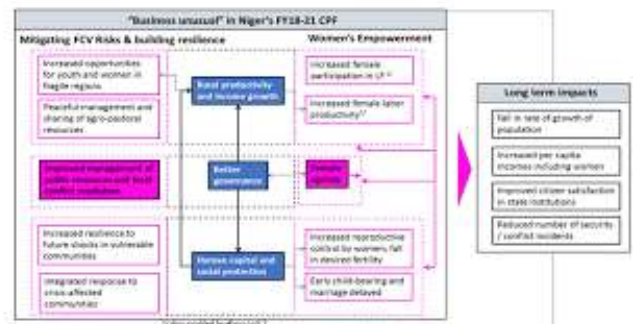


Fig. 2. The feasible and effective pricing techniques for oil spill

As mentioned above, losses due to each oil spill incident to the marine ecosystem can be scientifically determined with high reliability and accuracy by surveying and measuring specifically with the application. One or several of the above methods. However, for ongoing and probable incidents, it is necessary to quickly estimate the potential damage to propose solutions, the above methods are not applicable. It is necessary to have a method of quick assessment with high reliability and with legal value.

In order to meet these requirements, people sought to estimate the total loss of an ongoing or expected incident based on data from a series of investigated incidents. Practice shows that total losses from an incident are reflected in four main groups of factors: (i) The amount and toxic level of the pollutant; (ii) Economic value of the affected area; (iii) Geographical, hydrological, season and weather characteristics of the incident site, (iv) Pollution treatment time. Thus, the total loss function caused by the oil spill can be generalized as follows:

Total losses = f {Total factors of impact x corresponding effect factor; The total number of affected objects x corresponding loss coefficient; Hydrological characteristics,

seasons, weather; Cost of troubleshooting; Pollution time}.

Obviously, the greater the volume of oil spills, the higher the toxic level of the oil will cause more damage to the environment. The more valuable the incident in the region, the greater the economic loss. Geographic, hydrological, seasonal and weather characteristics govern the speed and direction of the spill. This is an important factor affecting the area and location affected. Time and timing are also influential factors. If the problem occurred during the breeding season it could bring about bigger damage than other times of the year. Troubleshooting time has a strong influence on limiting the consequences of damage. Preventing oil spills can reduce the cost of oil spill dredging, limiting coastal damage.

With a series of incidents surveyed, measured and assessed for damage, one can find the correlation between the impacting factor and the type of impacted object. These correlations at the confidence level, can be built into the set of impact coefficients (associated with impact factors), and loss coefficients (associated with value and vulnerability of impacted subjects.) to quickly estimate the total loss of incidents with some baseline information.

The set of coefficients built are not immutable indices but they need to be supplemented and adjusted for the following reasons: Firstly, the vulnerability level of objects in the ecosystem always changes with time. The changing environment makes many species decline their tolerance while many species mutate and increase this ability. Secondly, the economic value of each geographical region is constantly fluctuating; Human awareness of the value of objects in nature is also expanding. Thirdly, geographical and hydrological parameters are increasingly unpredictable. Without supplementing and updating this data, the coefficients will be increasingly distant from reality.

V. SOME ISSUES RAISED IN THE STUDY, ASSESSMENT OF ECONOMIC LOSSES DUE TO OIL SPILLS IN THE TERRITORY OF VIETNAM

Assessing economic losses due to environmental incidents in particular and environmental assessment in general are indispensable activities in the state management of economy, society and environment. This requirement is even more urgent given the risk that Vietnam is now seriously affected by global climate change. However, activities of evaluating ecosystems and the environment in general still face many difficulties. This is a field that is not entirely new but lacks the apparatus with necessary manpower, material resources and the legal framework for organization and operation. In the United States, the results of estimating the total value of damage from the CVM valuation method have been considered by the legal system of this country as a legal basis for lawsuits of oil spill damage in particular as well as environmental conflicts. General school (Bennett, 2001). A fundamental difficulty of this activity is the lack of background data, namely detailed statistics on environmental economics, fluctuations of environmental quality and the current state of pollution over time.

A number of ministries and agencies have conducted their own specialized evaluation activities. However, these activities are relatively independent on a small scale. In order

to build an important and consistent system of important data on environment and economy, the Government and concerned ministries and branches should soon implement necessary activities, including research and establishment. Organizational system of specialized agencies to measure and build a system of baseline data on the status of natural resources and environmental pollution in the territory of Vietnam.

For rapid assessment and evaluation activities, a medium-term program should be developed with the objective of systematically assessing the economic, environmental and social losses caused by natural disasters and umbrella incidents. environmental pollution nationwide with the orientation towards building a set of loss calculation coefficients according to impact factors and impacted subjects as a basis for building necessary legal documents for house management. Water on the environment.

The quantification of environmental resources values will contribute primarily to the information system for environmental management agencies to limit actions that cause environmental pollution and develop environmental protection policies. The key is to address important economic areas and national resources and make the environment an account in the national account system. In order to include environmental factors into the national account system, an environmental accounting tool is needed.

Finally, it is necessary to update changes in the assessment methods around the world in the context of increasing climate change and economic crisis.

VI. CONCLUSION

In order to prevent and minimize damage caused by oil spills at sea, many measures need to be implemented in a comprehensive manner such as legal framework, building resources, strengthening equipment and cooperation. to carry out activities from preparing, coping, overcoming and dealing with oil spill consequences. Up to now, a number of legal documents on oil spill incident response and handling have been issued, the system of central to local agencies has been gradually strengthened.

According to the current law, the "Oil spill response activities are all activities from the preparation, response, overcoming and settlement of oil spill consequences", of which "Responding to oil spills" Oil spills are activities that use forces, means, equipment and supplies to promptly handle, eliminate or minimize oil spills, "and" Remedy consequences of spills. " oil is the activities to clean the soil, water, ecosystems of the oil-contaminated area and measures to limit damage, restore the environment and environment after the oil spill. Oil spill recovery is one of the important stages to limit and restore the environment and ecosystem, however, up to now most regulations focusing on coping with oil spills, regulations on dealing with oil spills are still limited. Law on natural resources and environment of sea and islands in 2015 was the first legal document regulating oil spills. at sea and has provided a section on responding to and overcoming oil spills at sea, however, only one article has the content of provisions on dealing with oil spills at sea.

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