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ENVIRONMENTAL SENSITIVITY CATEGORIES FOR THE SHORELINE FROM MUI NE TO THE MOUTH OF TIEN RIVER IN RESPONSE TO OIL SPILL HAZARD

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ABSTRACT

As the natural characteristics and economic developments, the coastal zone from Mui Ne to the mouth of Tien River is very sensitive to oil pollution. For building the environmental managements and contingency planning, the map of environmental sensitivity regionalization is a required facility.

Environmental sensitivity indexes (ESIS) system is the important foundations for the map of environmental sensitivity regionalization, of which the shoreline sensitivity index system is one of the essential data.

Based on the shoreline sensitivity index system the studied area is ranked in five sensitive categories as following:

- Low sensitivity (ESIS-1): the capes of KeGa, Hotram, Kyvan, and Nghinh Phong.
- Moderate - low Sensitivity (ESIS-2) including the areas: from Phan Thiet to northern of Phanthiet, the shore of northern KeGa Cape and Phuochai shore
- Moderate sensitivity (ESIS-3): beaches from south of Kega cape to north of Hotram cape, from PhuocHai to KyVan Cape and of VungTau City;
- High Sensitivity (ESIS- 4): some beaches of VungTau and LongHai, and gulf of Phanthiet
- Extreme Sensitivity (ESIS-5): the shore from GanhRai gulf to the mouth of Tien River.

Key Words: contingency plan, clean-up, oil spill, spilled oil, sensitivity index, sensitivity index system, sensitivity map, exposed shoreline, moderate sheltered shoreline, well sheltered shoreline

Introduction

Coastal zone from Mui Ne to the mouth of Tien River is known as a prosperous area of diverse natural resources and dynamic economic activities of which the most important ones is petroleum industry activity both onshore and offshore. Therefore, a contingency plan in response to oil spill hazard is the pressing demand in regional environmental management. As an important tool of the contingency plan in response to oil spill the environment sensitivity map of which the shoreline environmental sensitivity is an essential part have been studied in recent years

Depending on the regional natural features, the sensitivity to oil pollution of the area from Muine to Tien River is evaluated upon the parameters as followings:

- The shelter of the shore.
- The penetration possibility of spilled oil.
- Times for oil retention on the shore and the possibility of natural clean-up.
- The impacts of spilled oil to economic activities and to ecological environment of the polluted shore and its surrounding.
- Possibility of response operation and shoreline clean-up.

Shoreline sensitivity index that are formed by analysing these parameters will be the base of the sensitivity classification for the studied area.

Factors impact on the dispersion and the invasion of spilled oil: *wind, waves, tide and surface flows*

Wind

Belonging to monsoon regime, wind in the studied area blows into two major directions:

Northeast direction: extending from November to March of the next year. During this time, wind direction can move from East to Northeast. Wind velocity that reduces from MUINE to the mouth of Tien River (from 7m/s to 2.1 m/s) and gets to maximum in February and March (5m/s - 5,7m/s).

Southwest direction: It extends from May to September, wind is not as strong as those in the Northeast monsoon, its velocity also reduces from MUINE to the mouth of TIEN River (from 5m/s to 2.1m/s). The minimum velocity is about in August.

April and October are the cut season periods, wind blows so weak that spilled oil, if it occurs, spreads slowly.

Storm occurs often from September to January of next year, its main directions are West-Southwest and West - Northwest. Historically the studied area did not belong to the windstorm hazard, however as the consequence of the change of climate there have been some strong storms that caused severe damages for coastal provinces. It must be mentioned that the damages would be heavier if oil spill happens at stormy time.

Waves

Because of the wind, wave is one of the important factors of coastline forming processes. When oil is spilled, wave throws spilled oil to the land and it causes many difficulties for the response operation, but at the same time wave is a positive factor of natural clean-up for spilled oil as well.

Depending on wind's intensity, high magnitude waves often appear in monsoon times. Commonly wave magnitude varies around 1.6m (in average) and 10.5m (maximum), wave cycle is about 5.5 second (average) and 11.5 second (maximum).

Tides

Tide is the significant factor in forming shoreline landform. Tide is also an important factor that brings spilled oil to inland.

As the common nature of the Southeast sea, most tides are irregular twice a-day. In the estuarine area tide regime varies rather complicatedly. In the eager time, tide's amplitude is about 3-4 meters. In neap tides, the amplitude can fall to 1.5 - 2.0 meters. The variation between neap and eager tide is not too large.

The topography of shoreline defines the invasion of tides to inland. Therefore, from MuiNe to VungTau, waves are the dominated hydrodynamics element, but in CanGio and in the other estuarine areas, tides play a dominated role.

Surface flows

– Nearshore currents

Playing the role of transportation and deposition of sediments and the role of shore erosion, nearshore currents are the major elements of the forming process of shoreline. In addition, the factor drifts spilled oil along the shore.

Nearshore current is affected not only by topography of sea floor and of coastline but also by tidal regime and monsoon.

+ *From MuiNe to KyVan Cape*

During Northeast monsoon time, the nearshore current flows to the Southwest with the velocity varying around 0.3 m/s to 0.4 m/s.

In Southwest monsoon time its velocity varies around 0.2m/s - 0.3m/s and its direction drives toward the South. In this time, in VungTau, it forms a sub-current driving towards offshore with the velocity varying from 0.4m/s to 0,5 m/s.

+ *From KyVan Cape to the mouth of Tien River*

The direction of nearshore current varies strongly after season: it flows from Southwest to West-Southwest with moderate velocity of 0.2 - 0.3 m/s in Northeast monsoon time; while in Southwest monsoon time its direction turns to Northeast and the current 's velocity is about 0.4m/s - 0.5 m/s.

- *Rivers and littoral flows system*

They are the ways bringing spilled oil to inland. Based on the characteristics and the density of the flows, the studied area is divided into two sections as followings:

+ *From MuiNe to KyVan Cape*

Flows dispose scatteredly; there are only some rivers as PhanRang, CaTy and some small streams. Most of them are short and sloping, they usually run out in dry season. As the regional topography is relatively high and rather steep, tides - even spring tides do not cause any remarkable effect. Thus, potential oily-impregnated parts caused by spilled oil will be very limited.

+ *From KyVan Cape to the mouth of Tien River*

Flows systems are widespread; they are large rivers as Dinh, ThiVai, Ray and the distributaries of SaiGon - DongNai River, VamCo River and Tien River. These channels are quite deep, wide, their bottom is gently sloping. As the consequence of the above features, during spring tide-seawater penetrates far to inland (from 50km to 100 km). Seawater propagative velocity is about 0.75-1.8 m/s.

From September to October, flows tend to pour themselves towards the sea. Contrarily, from March to April (dry season), via these flows, seawater invades to inland. The threatening from oil spill hazards not only comes from the sea but also from the flows caused by the activity of the fluvial commercial ports, e.g. Saigon port.

Shoreline sensitivity index system for the area from MuiNe to the mouth of Tien River

The protection of the shore

According to shelter parameter, the shoreline of the studied area is divided into three levels: exposed, moderate sheltered and well sheltered.

+ *Exposed shorelines*

They are headlands and beaches. The headland includes MuiNe, KeGa, HoTram, KyVan and NghinhPhong. The beaches are those extend from PhanThiet to KeGa Cape and from KyVan Cape to HoTram Cape.

In the sight of landform, they are rocky mounts (such as NuiLon, NuiNho (in VungTau), HonVung and ChauVien (in LongHai)...), wave-cut terraces, wave-cut cliff, pebble-sandy beach, marine terrace, dunes and sandbank. The dunes can outstretch from 300-400 m to 5 km. On the ancient dunes, there are many orchards.

Erosion that is the dominant process over this type of shoreline forms the eroded coastline types. Wind, waves, tides and nearshore currents play not only the important role of eroding and transporting shoreline

materials, but also the role of depositing eroded littoral ones. As consequence of such the facts, the eroded-deposited coastlines are formed.

+ *Moderate sheltered shores*

They are the shorelines of PhanThiet Guft, and CuaLap. As wave energy reduces, deposition and erosion occur at the same time. The flows from land provide significant quantities of sediment but their erosion activity is also significant too. Shoreline materials are fine grained such as sand, silt, and clay... Outwards the coast, submerged spits are often formed.

+ *Well sheltered shores*

They are wetland and lowland located in GanhRai gulf. As wave energy is usually low, deposition is the predominant process. Mainly the materials forming the shore are alluvium. Fine-grained materials, especially silt and clay, are predominant. As the elevation varies around 0-4 m, via the flows' channels tides play the major role in driving spilled oil to inland.

Submerged warps and spits extend along the shore. Toward the land, ancient spits form sandbars that can be recognized easily on satellite image. In due to the perched groundwater tables that often present in sandbars settlements have increased rapidly forming a typical residential distribution of the delta regions. In GanhRai Gulf mangrove forest with its the typical ecosystem is well increasing.

Penetration possibility of spilled oil

Firstly, it depends on the position of spill, then the regional topography, hydrology regime, and the shore materials.

Belongs to the position of potential oil spill GanhRai gulf is the most sensitive area because of the oil industry activity offshore and on land as well as of the activity of the sea port and fluvial ports. Penetration possibility of spilled oil increases with the increasing of shoreline sheltering, so it turns to very small at the exposed shoreline that is mentioned above.

The retention of spilled oil on the shore and the possibility of natural clean-up

These characteristics depend on topography, shoreline shelter, and especially the shore forming materials. The description for oil retention possibility based on the shore forming materials is presented in the table 1. In the studied area, spilled oil will be retained the most and the natural clean-up possibility will be the least on the shore of GanhRai Gulf.

Table 1. Spilled Oil retention possibility

<i>Shore type</i>	<i>Spilled oil retention possibility</i>
Rocky cliffs, rocky block platforms	Oil will be removed by waves within weeks.
Rocky and pebble platforms	Oil may penetrate rapidly into the stratum, it's hard to clean up, and oil may persist for years.
Coarse grained sandy beach, sand mixed rocky beach	Oil may penetrate rapidly and it's hard to clean up; oil may persist for years
Medium grained sandy beach	Oil may penetrate rapidly and it's relatively hard to clean up. Incase of the exposed shores oil can be cleaned up naturally within days or months.
Fine grained sandy beach	Oil may not be usually penetrated deeply; it may persist for months.
Sand mixed silt/mud beach	Oil may spread largely but it does not penetrate deeply. Clean - up is difficult, oil may persist for many years

The impact on economic activities

This is the most important index. Over the studied area, the main economic activities are industry, tourism, fishery, aquaculture, agriculture and forestry. For this index the most sensitive sections which are represented in figure 6 are GanhRai gulf; then PhanThiet gulf, the shorelines from KyVan Cape to NghinhPhong Cape and from KeGa Cape to HoTram Cape.

Possibilities of response and clean up

As the studied area is quite limited, this index addresses only on the ability of operation in response and clean-up activities. For this index, the mangrove forest of GanhRai gulf is the most sensitivity because it is too difficult to operate the response and clean up activities there.

Environment sensitivity categories of the shoreline from MuiNe to the mouth of Tien River

Basing on all environmental sensitivity index mentioned above, the shoreline of the studied area is ranked in five sensitive categories, which are represented in table 2. According to this classification each category is modified by the grade of environmental sensitivity index system (ESIS) that is composed from all five environmental sensitivity indexes.

Table 2. Shoreline Environmental Sensitivity categories from MuiNe to the mouth of Tien River.

<i>Grade</i>	<i>Shoreline sections</i>	<i>Description</i>
Low ESIS-1	MuiNe, KeGa Cape, HoTram Cape, KyVan Cape and NghinhPhong Cape	Exposed shorelines are formed from rocky blocks, sand/sand- pebble. Landform is high and steep; it's easy to clean up naturally. It's very hard for oil to intrude inland. Economic activities develop limitedly.
Medium-low ESIS-2	The section from MuiNe to the north of PhanThiet; the shoreline of the north of KeGa Cape and PhuocHai shoreline	Exposed and medium - sheltered shorelines are formed from sand (coarse to medium grained), and mud mixed sand. Surface flows are not widespread. Economic activities are not crowded. It is convenient for response and clean up operation.
Medium ESIS-3	The section from surrounding of KeGa Cape to HoTram Cape	Exposed and medium sheltered shorelines are formed from sand and mud mixed sand. Surface flows are relatively dense. Economic activities are quite developed. It's easy to operate the response and clean up activities
High ESIS-4	Beaches in VungTau and LongHai; the sections of PhanThiet gulf; and those from NuiLon to NuiNho	Medium sheltered shorelines, which are formed by coarse-fine grained sand. It is hard to clean up. Seasonal economic activities are well developed
Extremely High. ESIS-5	GanhRai gulf, CanGio and the mouth of Tien River	High sheltered shorelines formed with fine-grained materials. The land is low, surface flows is very dense. Oil may penetrate easily and may persist for long time. Clean-up operation is very difficult. Economic activities are crowded for year round. The risk of oil spilled hazards from both the shore and fluvial transportation is rather high.

Conclusion

In focus to the shoreline environment sensitivity, all of environment features, both natural and socio-economic, of the studied area are analysed precisely and composed selectively. The schema of the environment sensitivity grading of the shoreline from MUINE to Tien River is built as an illustration of the five categories of sensitivity.

The environment sensitivity classification of the shoreline from MUINE to Tien River will be the useful supportive tool not only for setting contingency plan in response to oil spill hazard but also for the coastal environment management planning.

It is necessary to mention that in future these categories could be changed by the change of some of these index. As the result the schema of the shoreline from MUINE to Tien River would be revised and fulfill with further data especially remote sensing data on coastal environment.

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