

## CHAPTER 5

### SUMMARY AND CONCLUSION

#### **5.1 Summary and Conclusions**

An oil spill is a release of a petroleum hydrocarbon into the environment due to human activity. The Strait of Malacca is one of the busiest maritime thoroughfares in the world (Ahmad and Hassan, 1983; Hii et al., 2009), with about a quarter of the oil in the global market transported through it, exposing the water and shoreline of the Strait to a constant threat of oil spill incidents, particularly the beaches of Pulau Pangkor.

Pulau Pangkor is situated in the middle-eastern part of the Strait and is very vulnerable to potential oil spill pollution by accidents of oil tankers. This study addresses the vulnerability of Pulau Pangkor to the threat of oil spills and assesses the consequences of an oil spill on the coastal facies of the island.

To investigate the potential impact of oil spills on Pulau Pangkor, various studies have been performed. Firstly, the zones of origin of oil spills in the Strait of Malacca that would affect Pulau Pangkor have been demarcated. Secondly, the coastal facies of Pulau Pangkor have been studied to understand their vulnerability towards oil spills. Thirdly, the oil spills impact on each coastal facies has been determined by running oil penetration tests. Lastly, mitigating measures have been suggested according to the potential effects of oil spills on the various coastal facies of Pulau Pangkor.

The findings of this study can be summarised as follows:

1. Oil spills have a different impact on different coastal facies. It is therefore essential to understand the geography and coastal facies distribution of Pulau Pangkor. Pulau Pangkor is essentially made up of granitic hills (Chan, et al.,

2010) and its western coastline, exposed to threats of oil spills, mainly consists of sandy beaches and rocky coastline with few mangroves (Jusoff, 2008; Chan et al., 2010) and mud flats. The beach sediments of Pulau Pangkor are mainly derived from the weathering and erosion of the granitic hills on the island. The beaches are mainly found on the western coastline of Pulau Pangkor with one beach, Teluk Dalam, on the northern coastline. The beaches on the western coastline are Belanga Bay, Teluk Nipah, Tortoise Bay and Pasir Bogak.

2. Oil spilled in the sea is usually transported to the coastal areas by wind and current (Ahmad and Hassan, 1983, Jalali et al., 1998). The dominant wave and current directions along the Strait of Malacca are from the northwest. Winds and currents from the southeast do occur but are secondary compared to the winds and currents from the northwest (Appendix 1). The areas of origin of potential oil spills from oil tankers accidents along the Strait of Malacca that could potentially affect Pulau Pangkor have been demarcated. Oil spills from oil tanker accidents that would occur to the northwest of Pulau Pangkor will affect Pulau Pangkor. However during stormy weather, any oil spill from oil tanker accidents along any part of the Strait of Malacca might be transported to Pulau Pangkor's beaches as current directions during this weather are unpredictable. This information is useful for the oil spill cleanup immediate contingency plans to take place (Samad and Mansor, 2002).
3. The impact of pollution by oil spills on the coastal facies of Pulau Pangkor is different according to the nature and composition of coastal facies sediments. Sediment transport along the coasts of Pulau Pangkor follows the direction of longshore currents, i.e. from north to south. Grain size distribution on the various beaches such as the southern part of the Teluk Nipah beach and the northern and southern parts of the Pasir Bogak beach is coarser to the north and finer to the south, confirming this general transport direction. The contrast in the proportion of carbonates on the beaches, with a larger proportion in the northern beaches and little to none in the southern beaches, suggest that the dynamics of sediment transport is very slow. Should an oil spill occur and reach the beaches of Pulau Pangkor, the oil would tend to settle on the beaches

and would not be removed or transported away by the slow, ineffective longshore currents. Oil and oil-impregnated sediments would have to be mechanically removed to clean up the beaches (Lewis, 1983).

4. The impact of an oil spill on beaches varies with different types of beach sediments (Ahmad and Hassan, 1983). The impact of oil spills on rocky coastlines will be less severe compared to oil spills on sandy beaches and mangroves as the oil slicks on rocky coastlines will be washed away by the next tide. The impact of oil spills on sandy beaches is dependent on the type of crude oil spilled and the grain size distribution of the beach sediments. The bigger the grain size, the deeper will the oil penetrate into the beach sediments. Beach sand with a high proportion of carbonate fragments will have a lower oil penetration rate compared to clastics beach sand as carbonates become oil-wet more easily than clastics. The deeper the oil penetrates into the subsurface, the more difficult will be the cleanup. The impact of oil spills on mangroves is severe as mangroves have high biodiversity (Sapari, 1987). The flora and fauna in the mangroves will be threatened.
5. Potential oil spills on Pulau Pangkor will affect this island in various ways. The economy of this island will be badly affected as cleanup measures are costly and income from the tourism industries will be affected. Harvests of fish from the sea will decrease causing the local industries to be badly affected as well. Both the flora and fauna along the coasts of the island will be at threat.
6. Oil spills can be prevented by anchoring booms in the shallow waters off the northwest and west coast or south and southeast of Pulau Pangkor to block potential oil slicks from reaching the beaches of Pulau Pangkor. The booms will divert the oil towards the south or north of the island, away from the beaches. This may give the authorities sufficient time to spray dispersants in containing the oil slicks before the next storm comes in.
7. In case an oil spill has reached the coasts of Pulau Pangkor, the appropriate response will most likely be the organisation of a clean-up campaign. Different coastal facies require different clean up techniques for optimal

efficiency. Mechanical removal is the best cleanup method (Schlacher et al., 2001) as it causes the least damage to the natural environment compared to other methods. The mechanical removal clean up method has to be prioritized from south to north starting from Pasir Bogak, to Tortoise Bay, followed by Teluk Nipah, Teluk Dalam and finally Belanga Bay.

## **5.2 Recommendations for further study**

Future studies are suggested on the geochemistry sediment polluted by oil spill and on the natural degradation of the oil slick, the scope of which is beyond that intended for this thesis.

The information acquired in this research would provide details required to formulate appropriate remedial management interventions and to inform both managers and the public about the real environmental consequences at the actual time frame relating to oil spills.