BEACH HAZARD: RIP CURRENT STUDY AND ASSESSMENT OF BEACH SAFETY AT SELECTED RECREATIONAL BEACHES ALONG PAHANG COASTLINE

BY

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ABSTRACT

Rip current is defined as a wave-induced current starting at nearshore and flowing to an offshore direction. Rip current is a major global coastal hazard and is responsible for over 30 drowning cases along the Pahang coastline from 2006 to 2018. However, there are still no data available on rip current at the East Coast of Peninsular Malaysia. Thus, this research was carried out to classify the beach morphodynamics associated with rip current formation at selected beaches along Pahang coastline (Balok, Batu Hitam, Teluk Cempedak, Air Leleh, and Sepat). Before these beaches were selected, preliminary data collection was done along Pahang coastline from Chendor beach, (at northern of Pahang) to Hiburan beach, (at Kuala Rompin in the south). The justification for selecting these beaches were based on several criteria such as presence of public activity, presence of coastal guard tower, near to a hotel and/or residential area, and easy public access. There were four stages of this research which included **1)** field sampling (samples collection) and beach profile survey. The output from this stage indicate the rip current probability at selected beaches; **2)** Determination of rip current occurrence probability based on the grain size and beach profile data. Findings from this second stage showed that four out of five recreational beaches (Balok, Batu Hitam, Teluk Cempedak and Sepat) had high potential in developing rip current; **3)** Determination of rip current occurrence and hazard at selected beaches during Southwest and Northeast monsoon. The results showed that Pahang coastline was categorized as rip-dominant intermediate beaches with several beaches were classified as barred (B), low tide terrace with rip (LTTR), and low tide bar and rip (LTBR). Beside, most of the beaches were exposed to different risk levels of rip current; high risk (Teluk Cempedak and Air Leleh beach), moderate risk (Balok and Batu Hitam beach), and mixed risk (Sepat beach); and last stage **4)** Survey on public knowledge of beach safety and rip current hazard among beachgoers at Teluk Cempedak beach. The results indicated that most of the beachgoers had limited knowledge on beach safety and rip current hazard. This study would be useful to educate public on the rip current hazard which might cause drowning. Thus, this can reduce the drowning cases in Malaysia, particularly in Pahang.

خلاصة البحث

يُعرَّف تيار التمزق بأنه تيار ناتج عن موجة يبدأ من الشاطئ القريب ويتدفق في اتجاه، بعيداً عن الشاطئ. يمثل تيار التمزق خطرًا ساحليًا عالميًا كبيرًا وهو المسؤول عن أكثر من 30 حالة غرق على طول ساحل باهانج من عام 2006 إلى عام 2018. ومع ذلك، لا توجد حتى الآن أية بيانات متاحة عن تيار التمزق في الساحل الشرقي لشبه جزيرة ماليزيا. لذلك، تم إجراء هذا البحث لتصنيف الديناميكا الشكلية للشاطئ المرتبطة بتكوين تيار التمزق في شواطئ مختارة على طول ساحل باهانج (بالوك، باتو هيتام، تيلوك سيمبيداك، إير ليليه، وسيبات). قبل اختيار هذه الشواطئ، تم جمع البيانات الأولية على طول ساحل باهانج من شاطئ تشيندور (في شمال باهانج) إلى شاطئ هيبوران (في كوالا رومبين في الجنوب). استندت مبررات اختيار هذه الشواطئ إلى عدة معايير مثل وجود نشاط عام، ووجود برج حرس ساحلي، بالقرب من فندق ومنطقة سكنية، وسهولة الوصول العام. كانت هناك أربع مراحل من هذا البحث والتي تضمنت ١) أخذ العينات الميدانية (جمع العينات) ومسح صورة الشاطئ. يشير الناتج من هذه المرحلة إلى احتمال التمزق الحالي في شواطئ مختارة ؛ ٢) تحديد احتمالية حدوث التمزق الحالي بناءً على حجم الحبوب وبيانات الملف الشخصي للشاطئ. أظهرت النتائج من هذه المرحلة الثانية أن أربعة من أصل خمسة شواطئ ترفيهية (بالوك، باتو هيتام، تيلوك سيمبيداك وسيبات) لديها إمكانات عالية في تطوير تيار التمزق؛ ٣) تحديد معدل حدوث التمزق والمخاطر في شواطئ مختارة خلال الرياح الموسمية الجنوبية الغربية والشمالية الشرقية. أظهرت النتائج أن ساحل باهانج تم تصنيفها على أنها من الشواطئ الوسيطة المهيمنة مع العديد من الشواطئ تم تصنيفها على أنها ذات قضبان منخفضة المد والجزر مع التمزق وقضيب المد والجزر المنخفض. إلى جانب ذلك، تعرضت معظم الشواطئ لمستويات مختلفة من مخاطر تمزق التيار؛ مخاطرة عالية (تيلوك سيمبيداك وشاطئ طيران ليلى)، مجازفة معقولة الى حد ما (بالوك وحجر أسود شاطئ بحر) والمخاطر المختلطة (شاطئ سيبات)؛ والمرحلة الأخيرة ٤) مسح حول المعرفة العامة بسلامة الشواطئ وتبديد المخاطر الحالية بين مرتادي الشواطئ في تيلوك سيمبيداك شاطئ. أشارت النتائج إلى أن معظم مرتادي الشواطئ لديهم معرفة محدودة بسلامة الشواطئ ومخاطر التمزق الحالية. قد تكون هذه الدراسة مفيدة لتثقيف الجمهور حول مخاطر التمزق الحالية التي قد تسبب الغرق. وبالتالي، يمكن أن يقلل من حالات الغرق في ماليزيا، وخاصة في باهانج.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Biosciences)

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DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF SYMBOLS

Ω	Dimensionless fall velocity
W_s	Sediment fall velocity
T	Wave period (in seconds)
H_b	Breaking wave height (in meter)
υ	Kinematic viscosity of fluid (υ = 1.0 x 10^{-6} kg m^{-1} s^{-1})
R	Submerged specific gravity (1.65 for quartz in water)
D_{50}	Sediment grain size, D_{50} (m)
ξ_b	Surf similarity (type of wave breaker)

LIST OF ABBREVIATIONS

NOAA	National Oceanic and Atmospheric Administration
SWM	Southwest monsoon
NEM	Northeast monsoon
LBT	Longshore and Bar Trough
RBB	Rhythmic Bar beach
TBR	Transverse Bar beach
LTT	Low Tide Terrace
RTR	Relative tide range
TR	Tidal range
LEO	Littoral Environment Observation
R	Reflective beach
B	Barred beach
LTTR	Low Tide Terrace with Rip beach
BD	Bar Dissipative beach
LTBR	Low Tide Bar with Rip beach
NBD	Non-Barred Dissipative beach
UD	Ultra-Dissipative beach
GPS	Global positioning system

CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

Beach is a landform alongside a body of water that consists of loose particles which include rock, sand, gravel, pebbles, and cobblestones. The beach receives the impact of wave and ocean current action that carry the loose particles away from the coast and change its morphodynamic. It is one of the preferred recreational areas, attracting a great number of people for ecotourism, thus becoming an important economic and social factor for the coastal regions. In Malaysia, ecotourism is defined as travel and visitation to nature areas in order to enjoy and respect the nature, contribute and promote to conservation activities, presence education and awareness component, provide the benefit to local communities which are sustain the ecology, socio-economy, culture and ethics (National Ecotourism Plan, 2017). The rapid development of tourism along the beach made the coastal areas suffer the direct effects from these tourism and recreational activities such as beach hazard, pollution, erosion, and habitat loss.

Beach hazards are coastal environments that are exposing the public to harm. According to Short and Hogan (1994), hazards are any phenomena or events that threaten people's life and their activity. The harmful situations may arise from the natural beach, surf zone processes, and morphology in the surf zone that bring swimmers seaward involuntary which causes drowning. Beach safety is referred to as the recognition of beach hazards that helps to reduce and prevent the hazards from happening. The hazard considered in this study is not coastal erosion, shoreline changes, biological or chemical hazard, but hazard related to the condition of ambient beaches

that are responsible for the drowning of hundreds and thousands annually. Every beach is known to have specific physical characteristics that contribute to the occurrence of harmful hazards.

There are five known characteristics of beach hazard which include water depth, surf zone and beach topography, surf zone current, breaking wave, and local hazards such as tidal current, reef structure, offshore wind, and rocky shore platform (Short and Hogan, 1994). However, based on a report by National Oceanic and Atmospheric Administration website (NOAA, 2018), there are nine (coastal and beach hazard) which could happen at beaches; rip current, shore break, lightning, tsunami, shark attack, jellyfish, excessive heat and sunburn, harmful algal bloom, and poor water quality. Among these hazards, rip current is at the top of the list. It is generally considered as the most hazardous event because it happens at surf zone, dragging beachgoers and swimmers to deep water area without their consent within minutes, combined with moderate to strong current that flows seaward at increasing channel depth and it is also important feature because of its role in shaping the beach through the transport of sand, mixing it with surf zone water and flushing it to deep water offshore. Rip current can occur at many types of beaches worldwide under a variety of tidal level and wave condition (Dalrymple et al., 2011).

Beaches are a potential hazard to people since beachgoers, swimmers, and bathers enter the surf zone, despite it being considered as no man's land in many coastal countries that need to be avoided at all cost. This is due to the increasing attractive locations for tourism, residential, and recreational development, that safety and precaution have been slowly neglected. This development trend will continue throughout the world as tourism and recreation continue to spread along the coast.

1.2 PROBLEM STATEMENT

Pahang has numerous beautiful beaches along its coastline and they are commonly famous tourist attractions and destinations (Wan Suzita Wan Ibrahim, 2016). However 'rip current hazard' can influence the suitability of a coastal area for recreational use, as it might effect the safety of beachgoers and the public. Study the degree of hazard in the surf zone area due to rip currents is crucial to protect human life and safety while maintaining tourist attraction. Nearly 24 fatal cases related to beach drowning were recorded from 2012 to 2017 in Pahang which might due to the rip current occurrence together with human error such as the lack of swimming skill and panicking (Fire and Rescue Department Malaysia, Malaysia Civil Defense Force). In Malaysia, there are many studies related to wave and wind, shoreline changes, coastal erosion, beach state of various places and states, but not hazardous rip current. Furthermore, rip current study in Malaysia is not as well studied and documented. The output from this study is beneficial to the Pahang State Government, Town and Regional Planning, and other related agencies in coastal development and management.

1.3 RESEARCH HYPOTHESES

1. Beach morphodynamic at five beaches along Pahang coastline can be classified into reflective, intermediate and dissipative beach state with eight groups which are reflective (R), low tide terrace with rip (LTTR), low tide terrace (LTT), barred (B), low tide bar with rip (LTBR), barred dissipative (BD), non-barred dissipative (NBD) and ultra-dissipative (UD).
2. The presence of rip currents is possible identify during different physical environment impacts (monsoon impact) such as wave and tidal action.

3. The low level of public knowledge on beach safety and rip current hazard among the beach goer are distinct according to swimming ability, signage warning at the beach and ability to identify rip current pattern using photography.

1.4 RESEARCH OBJECTIVES

This research aimed to identify and recognize the potential of recreational beaches to develop rip currents based on field measurement of beach profile, sediment analysis, and numerical modelling. To fulfil the above consideration, the specific objectives of this research are as follow:

1. To identify beach profile, sediment characteristic and rip current occurrence based on drowning cases and beach morphodynamic classification at five beaches along Pahang coastline.
2. To investigate rip current occurrence during different monsoon condition (Southwest and Northeast monsoon) along Pahang coastline.
3. To determine level of public knowledge on rip current and beach safety in Teluk Cempedak beach

1.5 THESIS OUTLINE

The thesis consists seven different chapters which are arranged consecutively according to a paper-based format. The first chapter is an introduction that introduces the overview background of the research, problem statement and hypotheses. The objectives were also including in this chapter.

Chapter 2 presents the literature review that is composed of important points and knowledge of past studies that relate to the worldwide coastal hazard, beach hazard and beach safety along the Pahang coastline, and factors that contribute to the beach hazard. The suitable procedure and methodology chosen to achieve the objectives and to conduct data collection are detailed and summarized in Chapter 3 alongside multiple analysis techniques including preliminary survey, drowning cases, beach survey, sediment analysis, littoral environment observation, beach morphodynamic model, aerial photo survey using drone images, numerical modelling, and beach safety survey.

The three main chapters of the thesis (4 – 6) describe the morphodynamics of selected recreational beaches at the East Coast, Peninsular Malaysia, focussing at the Pahang coastline region. To summarize, Chapter 4 presents the early assessment for this study known as a preliminary survey that gives an early overview about beach morphology and sediment characteristic, and provides insight on the rip current study at selected recreational beaches based on collected data and previous research data. This chapter also indicates the beaches that rip current may develop. Chapter 5 discusses the short-term study on rip current occurrence at selected beaches along the Pahang coastline from seasonal monsoons which include southwest monsoon (dry season) and northeast monsoon (wet season). Chapter 6 discusses and elaborates on the awareness of beach safety and its knowledge among visitors. Finally, Chapter 7 conclude the research finding and output in summary.

CHAPTER TWO

LITERATURE REVIEW

2.1 WHAT IS RIP CURRENT?

Rip currents are the greatest beach hazard that occurs at the surf zone. These currents known as natural phenomena are influenced by tide, wind, wave, and beach morphology that only happen at sandy beaches' surf zone (Castella et al., 2013). Rip current was firstly named by Shepard (1936) and is described as strong, jet-like, and narrow current that flows seaward from surf zone and extends beyond to point of breaking wave. During its first discovery, this hazardous current was known as riptide and undertow current by the public, swimmers, and beachgoers. Later, Shepard (1936) wrote and discussed 'undertow, rip current, and riptide' based on his observation in a *Science* article. He corrected and suggested that 'riptide' is not an appropriate term for this natural phenomenon because this hazardous current is generated by wave breaking and not by the tide. He also corrected the undertow term used to describe this rip current because there was no current pulling under the water. There are different characteristics that define rip current, riptide, and undertow as shown in Appendix I. Rip current is not only a threat to beach safety, beachgoers, and swimmers, it is also responsible for shoreline changes by transporting sediment offshore (Cooke, 1970; Komar, 1971; Short, 1999).

Further research on these hazardous currents was carried out by Shepard and Inman (1950) who clarified that there were many effects which contribute to rip current occurrence and formation. Besides, there were also research and studies related to the