IVESTIGATION OF GEOMORPHIC AND COASTAL GEOLOGY OF THE MALAYSIAN BAYS FREQENTED WITH HABs OCCURRENCE USING REMOTE SENSING DATA

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ABSTRACT

Malaysian bays are considered vulnerable to the impacts of climate change and frequented with Harmful algal blooms (HABs). Rising in sea level, shoreline erosion, stresses on fisheries, population pressure, interference of land-use and lack of institutional capabilities for integrated management make major challenges. Increasing frequency, intensity, and geographic distribution of HABs poses a serious threat to the coastal fish/shellfish aquaculture and fisheries in Malaysian bays. Recent investigations and satellite observations indicate HABs originated from specific coast that have favorable geographic, geomorphic and coastal geology conditions to bring the green macro algae from the coast offshore. Therefore, the identification of high HABs frequented bays using remote sensing and geology investigations in Malaysian waters is required to reduce future challenges in this unique case. This research implemented comprehensive geomorphic and coastal geology investigations combined with remote sensing digital image processing approach to identify Malaysian bays frequented with HABs occurrence in Malaysian waters territory and the impacts of climate change on coastal shoreline. The landscape and geomorphological features of the Malaysian bays were constructed from remote sensing satellite data such as Landsat-8 and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) combined with field observations and surveying. The samples for laboratory analysis were collected from the sediment stations with different distance across shorelines features and watersheds of the Malaysian bays. This research identified that semi-enclosed bays with connection to estuaries have high potential to be frequented with HABs occurrence, which will assist to reduce future challenges in this unique case in Malaysian waters territory.

1. INTRODUCTION

One the most acute and commonly recognized symptom of eutrophication in marine and freshwater environments is harmful algal blooms (HABs). HABs occur in many regions of the world and involve toxic and harmful phytoplankton. Harmful algal blooms can cause fish kills, human illness through shellfish poisoning, and death of marine mammals and shore birds (Anderson, 2002). The most conspicuous effects of HABs on marine wildlife are largescale mortality events associated with toxin producing blooms. Harmful algal blooms are often referred to as “red tides” or “brown tides” because of the appearance of the water when these blooms occur. One red tide event, which occurred near Hong Kong in 1998, wiped out 90 percent of the entire stock of Hong Kong’s fish farms and resulted in an estimated economic loss of $40 million USD (Lu and Hodgkiss, 2004). Malaysian bays are considered vulnerable to the impacts of climate change and anthropogenic activities. In addition to the expected rise in sea level, shoreline erosion, stresses on fisheries, population pressure, and interference of land-use and lack of institutional capabilities for integrated management make major challenges. Remote sensing satellite data monitoring and geological investigations are capable to show definite changes in coastal morphology and landscape of the Malaysian bays. Harmful algal blooms (HABs) occur frequently in the South China Sea, causing enormous economic losses in aquaculture. South China Sea is surrounded by Malaysia, Thailand, Vietnam, Brunei, Indonesia, Philippines and China. Areas with frequent HABs include the Pearl River Estuary (China), the Manila Bay (the Philippines), the Masinloc Bay (the Philippines), and the western coast of Sepanggar bay (Sabah Malaysia). Variations in HABs are related to various regional conditions, such as a reversed monsoon wind in the entire South China Sea, river discharges in the northern area, upwelling in Vietnam coastal waters during southwest winds and near Malaysia coastal waters during northeast winds, and eutrophication from coastal aquaculture in the Pearl River estuary, Manila Bay, and Masinloc Bay (Wang et al., 2008). Nutrient enrichment, especially phosphorus (P) and nitrogen (N), has been considered as a major threat to the health of coastal marine waters (Andersen et al., 2004). Increasing frequency, intensity, and geographic distribution of HABs poses a serious threat to the coastal fish/shellfish aquaculture and fisheries in Malaysian bays. Recent investigations and satellite observations indicate HABs originated from specific coast that have favourable geographic, geomorphic and coastal geology conditions to bring the green macroalgae from the coast offshore (Wang et al., 2008; Liu et al., 2013; Siswanto et al., 2013). Therefore, the identification of high HABs probability bays using remote sensing and geology investigations in Malaysian water is required to reduce future challenges in this unique case.

2. MATERIALS AND METHODS

2.1 Remote sensing data

In this investigation, mosaic ScanSAR mode dual polarization (level 3.1) PALSAR-2 scenes were obtained from ALOS-2 data distribution consortium online system Remote Sensing Technology Center of Japan (RESTEC) (http://www.restec.or.jp/english/index.html) for comprehensive analysis of major structural features of Peninsular Malaysia bays at regional scale. A level 1T (terrain-corrected) Landsat-8 OLI image was obtained through the US Geological Survey Earth Resources Observation and Science Center (http://earthexplorer.usgs.gov) for southern part of Peninsular Malaysia. The image data (LC81250592013178LGN01) (Path/Row 125/59) were acquired on June 27, 2013. The image data cover Johor Bahru state and the scene has 8.33 percent cloud cover. The data were processed using the ENVI (Environment for Visualizing Images) version 5.2 and Arc GIS version 10.3 software packages.

2.2 Field observations and surveying

Coastal Geology refers to the origin, structure, and characteristics of the sediments that make up the coastal region, from the uplands to the nearshore region. The sediments and geology that compose a particular coastline is the product of physical and chemical processes that take place over thousands of years. Fieldwork was conducted during a scientific expedition in Johor Bahru bays, Estuaries and surrounding terrains between 20 and 25 May 2015, to collect sample for laboratory analysis from the sediment stations with 10m, 100m and 1000m distance across shorelines features and Estuaries and watersheds. GPS survey was carried out using a Garmin® MONTERRA® with an average accuracy 5 m in sample collected location points in the study area. Organic materials such as N, P, Fe, Na, Ca, Si and C in sediment samples were analyzed by X-ray fluorescence spectrometers (XRF) technique and compared with recent algal bloom events. Field view and outcrop photographs were taken of the geomorphology and structural elements.

2.3 Data analysis

The presence of speckle in Synthetic Aperture Radar (SAR) images reduce the detectability of ground targets, obscures the spatial patterns of surface features, and decreases the accuracy of automated image classification. Therefore, it is necessary to treat the speckle by filtering the data before it can be used in various applications (Lee and Jurkevich, 1994; Sheng and Xia, 1996). To fulfill the aim of this study, the median spatial convolution filter was used for noise removal and smoothing the PALSAR images. The median filter is a particularly useful statistical filter in the spatial domain, which effectively remove speckle (salt and pepper noise) in radar images without eliminating fine details (Pour and Hashim, 2014, 2015a,b; Schowengert, 2007). The RGB color composites additive primary colors allow the assignment of three different types of information (e.g image channels) to the three primary RGB colors. The color composite facilitates the interpretation of multichannel image data due to the variations in colors based on the values in the single channels (Pour and Hashim, 2011a, b). The RGB technique was applied to Landsat-8 OLI image of Johor Bahru.

3. RESULTS AND DISCUSSION

Mosaic ScanSAR was used for comprehensive analysis of major geomorphic and coastal geology of Malaysian bays at regional scale for Peninsular Malaysia. Synthetic Aperture Radar (SAR) has a special feature of being able to observe regardless of time (day and night) and all-weather conditions. Figure 1 shows RGB colour-composite of HH, HV and HH+HV polarization channels for Peninsular Malaysia. The RGB colour-composite yields an image with great structural details and geomorphological information for Malaysian bays in Peninsular Malaysia. Geomorphic coastal features such as cuspate foreland, tombolo, spits, bay, lagoon, barrier Island and estuary are observable in figure 1.

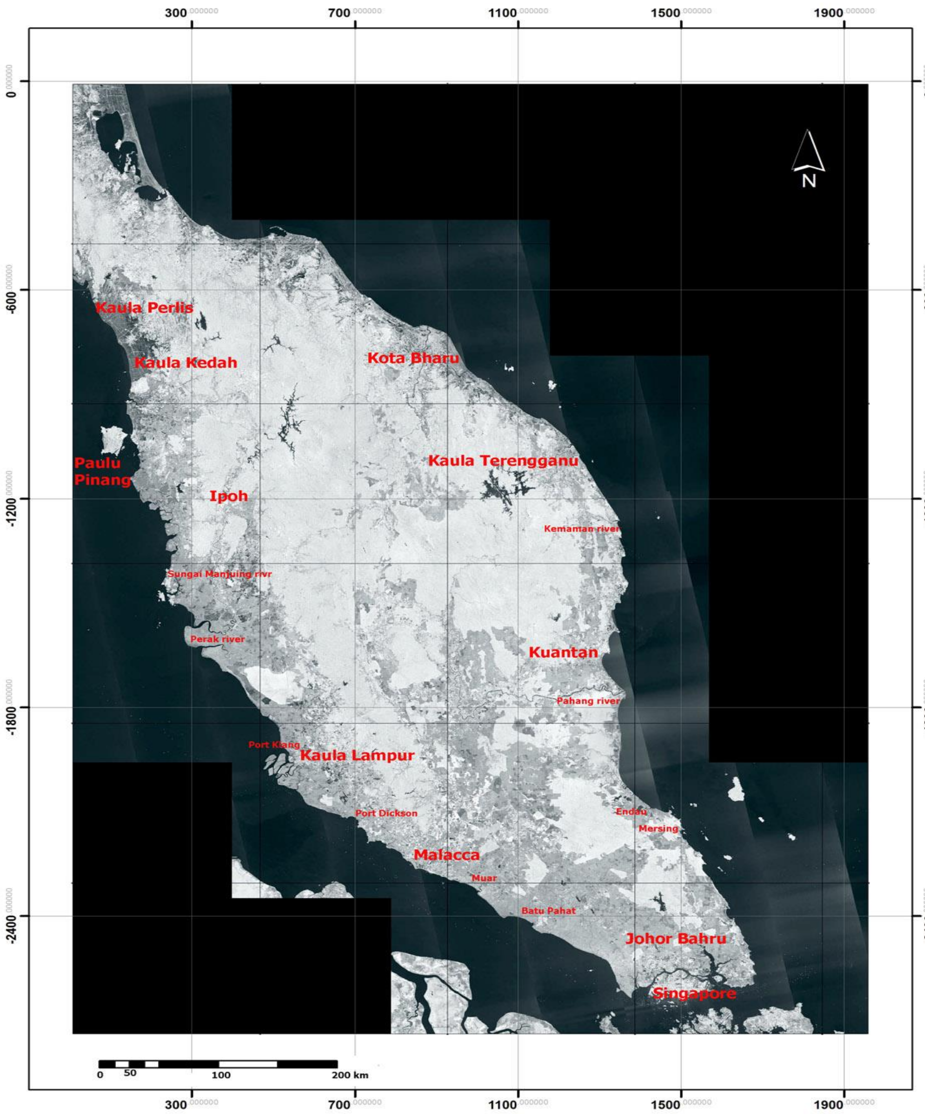

Figure 1. RGB colour combination (HH, HV and HH+HV polarization channels) of mosaic ScanSAR scene covering Peninsular Malaysia.

Several estuaries such as Johor Bahru estuary, Pahang estuary, Perak estuary are connected to Malaysian bays, which are located near cites and agriculture land. Estuary is a semi enclosed, elongated coastal basin that receives an inflow of both freshwater and saltwater. The plumbing of cities to supply water for drinking and fire protection and to remove water from sewage, industrial waste, and storm water runoff made it easy to transfer nutrients (especially N and P input) from the land to coastal waters. HABs can be greatly accelerated by human activities that increase the rate of nutrient input in a water body, due to rapid urbanization, industrialization and intensifying agricultural production. Accordingly semi-enclosed bays with connection to estuaries in Peninsular Malaysia have high potential to be frequented by HABs. Algal bloom could occurred during wet season in Malaysian bays, when the environmental conditions are favourable and nutrient loading to the estuaries from watershed increase through runoffs that carry down overused fertilizers from agroecosystems and/or discharged human waste from settlements. N and P input and enrichment in water are the most primary factors to induce water eutrophication. Incensement in nutrient loading can alter the habitat, physicochemical structure and food webs (Yang et al., 2009).

Figure 2 shows RGB colour-composite of band 5 (near-infrared: 0.845-0.885 μm), band 6 (shortwave infrared: 1.560-1.660 μm) and band 7 (shortwave infrared: 2.100-2.30 μm) of the Landsat-8 data for Johor Bahru estuary. The textural features of Johor Bahru watershed are recognizable in this RGB image. Urban regions appear as grey colour in southern part of the image. These regions are Johor Bahru city and Singapore, which are constructed in the bank of Johor Bahru River. Several agricultural farms in the Johor Bahru watershed manifest as light brown colour in figure 2.

Results derived from laboratory analysis show that many of sediments samples have high percentages of N, P, Fe, Na, Ca, Si and C. Consequently, heavy monsoon rainfall (wet seasons from September to December and February to May) in Johor Bahru river basin caused excessive loading of nutrients into water bodies.

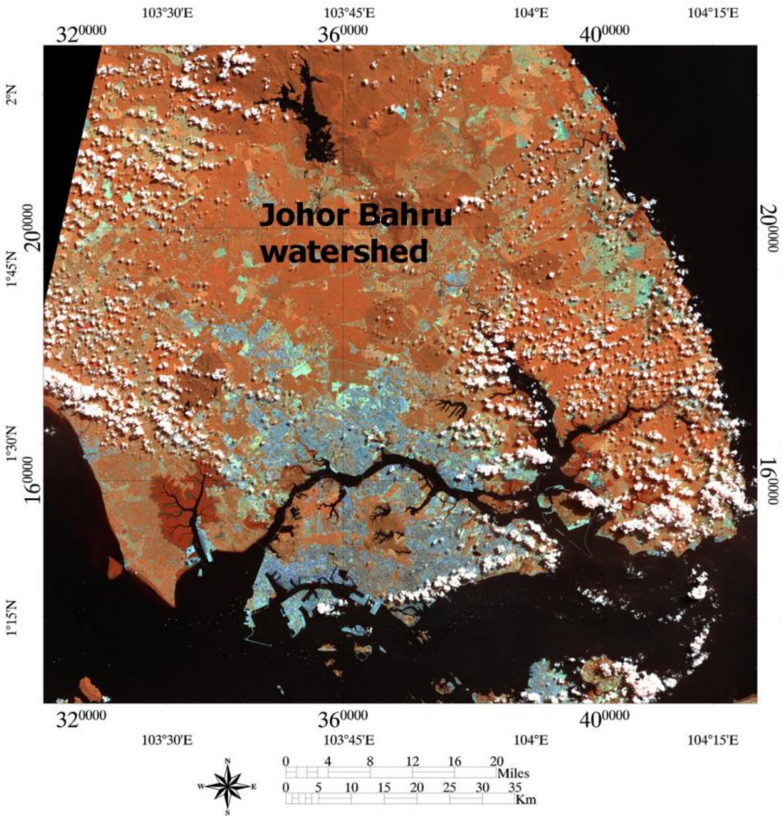

Figure 2. RGB colour combination) of bands 5,6 and 7 of Landsat-8 cover Johor Bahru watershed .

Autotrophy algae blooming in water normally can be seen after flash flooding in Johor Bahru and Singapore bays, which composes its bioplasm by sunlight energy and inorganic substances through photosynthesis as follows:

$$106CO2+ 16NO^{-}3 + HPO^{-2}\,4 +122H2O+18H^{+} \longrightarrow C106H263O110N16P \text{ (bioplasm of algae)}+138O2 \quad (1)$$

According to above equation, it can be concluded that inorganic nitrogen and phosphorus are the major control factors for the propagation of algae, especially phosphorus. Catastrophic losses in seagrass meadows and aquatic ecosystem are occurred, especially in flushed estuaries like Johor Bahru estuary, coastal embayments and lagoons where nutrient loads are both large and frequent.

Water eutrophication is mainly caused by excessive loading of nutrients into water bodies like N and P. Excessive nutrients come from both point pollution such as waste water from industry and municipal sewage, and non-point pollution like irrigation water, surface run water containing fertilizer from farmland, etc. Increased nutrient load to water body is now recognized as a major threat to the structure and functions of near shore coastal ecosystems, and severe eutrophication problems associated with harmful algal bloom is a major manifestation. Although related to nutrient enrichment in general, the basic cause of water eutrophication is more connected to an imbalance in the load of nitrogen and phosphorus with respect to silica (Dauvin *et al*., 2007). The influencing factors of water eutrophication include: (1) excessive N and P, (2) slow current velocity, (3) adequate temperature and favorable other environmental factors, and (4) microbial activity and biodiversity (Li and Liao, 2002). Water eutrophication may occur rapidly when all of these conditions are favorable.

4. CONCLUSIONS

Studying and managing nutrient pollution and eutrophication in tropical coastal environments is a major and immediate challenge for marine ecology in Malaysian bays. Future nutrient pollution and coastal marine eutrophication will vary greatly in different parts of the world, with the greatest increases in Asia. As in the past, nutrient pollution will follow economic expansion and population growth. Southeast Asia is the most threatened, with over 80% at risk, mainly from coastal development and overfishing. Water eutrophication can be greatly accelerated by human activities that increase the rate of nutrient input in a water body, due to rapid urbanization, industrialization and intensifying agricultural production. Results of this investigation indicate that the many Algal blooms are caused by a major influx of nutrient rich runoff into a water body in Malaysian bays, programs to treat wastewater, reduce the overuse of fertilizers in agriculture and reducing the bulk flow of runoff can be effective for reducing severe algal blooms at river mouths, estuaries, and the ocean directly in front of the river's mouth.

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