CHARACTERISTICS AND DYNAMICS OF SEDIMENT AT MARUDU BAY, SABAH, MALAYSIA

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UNIVERSITI MALAYSIA SABAH
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I affirmed that this dissertation is the result of my own work, except for quotations and summaries, each of which has been fully acknowledged.

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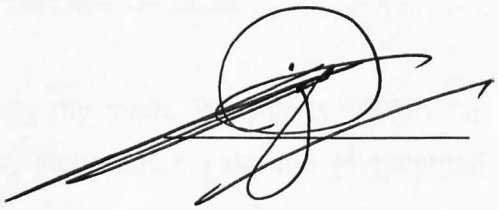

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` Twenty years from now you will be more disappointed by the things that you didn't do than by the ones you did do, so throw off the bowlines, sail away from safe harbor, catch the trade winds in your sails. Explore, Dream, Discover.'

-Mark Twain-

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ABSTRACT

Marudu Bay lies between the geographical coordinates of 6.9511°N - 7.0373°N and 116.7420 °E – 117.0339 °E where some part of the Bay is under the Tun Mustapha Park (TMP) area that has been gazetted as Malaysia's largest marine protected area. Rapid coastal development and land clearing for aquaculture activities leads to high sediment discharges that may affect the Bay by damaging its marine resources. Hydrodynamic factor plays an important role in the movement of the sediment within the Bay, and it is affected by river discharge, geomorphology of the bay, bathymetry and tidal constituent. The current study aimed to identify the grain size, distribution, and characteristic of surface sediment at the seabed in inner and outer part of Marudu Bay during northeast, inter-, and southwest monsoon. These data then were simulated for hydrodynamic and sediment dynamic during northeast monsoon via Delft3D simulation model. The model set-up of Delft3D simulation was calibrated and verified using field measurements of data, such as water level, current speed and current direction. The field data for current verification were measured using Acoustic Wave and Current profiler deployed on 12 - 25 March 2015 in the middle of the Bay. The surface sediment and water samples were collected at specific date from 45 stations within the Bay using Ponar grab and horizontal water sampler. Subsequently, the sediment and water samples were then analysed using the LISST-Portable Laser Diffraction Size Analyser and standard method in determination of Total Suspended Sediment (TSS), respectively. The composition of silt and sandy silt (7.92 – 68.18 μm) content in the surface sediment samples from entire Marudu Bay (n=38) was dominant with about 90 % and 40 %, respectively. Sand and silty sand (94.94 – 250 μm) composition present only at the certain area (n=7) with 98 % and 80 %, respectively. Highest TSS value was found at ST26 with 14.1 mg/L which located near Telaga river. Overall from 45 sediment samples obtained at Marudu Bay, for sorting characteristic group; (i) 43 samples were poorly sorted and 2 were well sorted, (ii) 33 samples were under coarse skewed and another 12 under fine skewed, and (iii) 38 samples under mesokurtic and 7 under leptokurtic. The hydraulic movement during the ebb and flood tide were uniforms where the water enters and out from the Bay through Cape of Simpang Mengayau. During spring ebb tide (-0.58 m) the surface sediments from inner and outer part of the Marudu Bay were transported out at the rate of $0.1x10^6$ to $0.2x10^6$ $m^3/s/m$ and $0.2x10^6$ to $0.4x10^6$ $m^3/s/m$ with a mean current speed of 0.13 m/s. While during spring flood tide (0.28 m), the surface sediments were transported into the Bay at the rate of $0.4x10^6$ to $1.8x10^6$ $m^3/s/m$ with a mean current speed of 0.09 m/s. Usage of silt curtain need to be implemented as mitigation measure to minimize the sedimentation. Findings of this present study provide baseline information on sediment transport and hydrodynamic pattern within the Marudu Bay to decision-makers in developing sustainable aquaculture activities.

ABSTRAK

CIRI-CIRI DAN DINAMIK SEDIMEN DI TELUK MARUDU, SABAH, MALAYSIA

Teluk Marudu terletak diantara koordinat geografi 6.9511°N - 7.0373°N dan 116.7420 °E – 117.0339 °E di mana sebahagian daripada kawasan teluk tersebut berada di bawah Taman Tun Mustapha yang telah diwartakan sebagai kawasan perlindungan marin terbesar di Malaysia. Aktiviti pembangunan dan pembukaan tanah yang pesat untuk aktiviti akuakultur menyebabkan pelepasan sedimen yang tinggi ke kawasan teluk dimana ianya akan menyumbang kepada kerosakkan sumber marin. Faktor hidrodinamik memainkan peranan yang penting dalam pergerakan sedimen di Teluk Marudu dan ianya dipengaruhi oleh faktor pasang surut, aliran sungai, geomorfologi dan kedalaman air. Kajian ini bertujuan untuk menentukan saiz butiran, taburan dan ciri-ciri permukaan sedimen di kawasan dalam dan luar Teluk Marudu semasa monsun timur laut, peralihan dan barat daya. Kesemua data yang diperoleh disimulasikan untuk simulasi hidrodinamik dan dinamik sedimen semasa monsun timur laut dengan perisian simulasi model Delft3D. Persediaan simulasi model Delft3D dikalibrasi dan disahkan dengan menggunakan data paras air laut, kelajuan dan arah arus yang telah diukur di lapangan. Data arus di lapangan diukur dengan menggunakan 'Acoustic Wave and Current profiler' yang dipasang pada 12 – 25 Mac 2015 di kawasan tengah Teluk Marudu. Sampel permukaan sedimen di dasar dan sampel air diambil pada tarikh tertentu dari 45 stesen di seluruh kawasan Teluk Marudu dengan menggunakan alat pencekau tanah Ponar dan sampler air mendatar. Sampel sedimen dan air dianalisis menggunakan 'LISST-Portable Laser Diffraction Size Analyser' dan kaedah piawai dalam menentukan Jumlah Sedimen Terampai (TSS). Komposisi lumpur dan lumpur berpasir (7.92 – 68.18 μm) dalam sampel permukaan sedimen dari seluruh Teluk Marudu (n=38) adalah dominan dengan 90 % dan 40 %. Pasir dan pasir berlumpur (94.94 – 250 μm) masing-masing hanya terdapat di kawasan tertentu (n=7) dengan 98 % dan 80 %. Nilai TSS paling tinggi didapati di ST26 dengan 14.1 mg/L yang terletak berhampiran Sungai Telaga. Keseluruhan dari 45 sampel sedimen yang diperolehi di Teluk Marudu, bagi kumpulan "sorting"; (i) 43 sampel dalam kalangan "poorly sorted" dan 2 dalam "well sorted", (ii) 33 sampel berada dalam kalangan "coarse skewed" dan 12 yang lain dalam kalangan "fine skewed", dan (iii) 38 sampel dalam kalangan "mesokurtic" dan 7 dalam "leptokurtic". Pergerakkan hidraulik semasa air pasang dan surut pula menunjukkan keseragaman dimana air masuk dan keluar dari Teluk Marudu melalu kawasan Tanjung Simpang Mengayau. Semasa air surut besar (-0.58 m) sedimen di permukaan bagi kawasan dalam dan luar Teluk Marudu telah dibawa keluar pada kadar masing-masing, $0.1x10^6 – 0.2x10^6$ $m^3/s/m$ dan $0.2x10^6 – 0.4x10^6$ $m^3/s/m$ dengan min kelajuan arus 0.13 m/s. Semasa air pasang besar (0.28 m) pula,

sediment dipermukaan telah dibawa masuk ke dalam Teluk Marudu pada kadar $0.4x10^6 - 1.8x10^6$ $m^3/s/m$ *dengan min kelajuan arus 0.09 m/s. Penemuan daripada kajian ini menyediakan satu maklumat asas mengenai pergerakan sedimen dan corak hidrodinamik di Teluk Marudu kepada pembuat keputusan dalam membangunkan aktiviti akuakultur yang lebih mapan.*

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LIST OF ABBREVIATIONS

°E	degree east
°N	degree north
a.m	*ante meridien*, before midday
p.m	*post meridien*, after midday
1D	1-Dimensional
2D	2-Dimensional
3D	3- Dimensional
ADCIRC	Advanced Circulation
AWAC	Acoustic Wave and Current
BMRI	Borneo Marine Research Institue
CBP	Chesapeake Bay Program
CH3D-WES	Curvilinear Hydrodynamic in 3D – Waterway Experiment Station
DID	Department of Irrigation and Drainage Malaysia
ECOMSED	Estuarine and Coastal Ocean Model
FVCOM	Finite Volume Coastal Ocean Model
ha	hectares
H_2O_2	Hydrogen Peroxide
HCl	Hydrochloric acid
IHO	International Hydrographic Organization

K_1	lunisolar diurnal constituent
K_2	lunisolar semi-diurnal constituent
M_2	principal lunar semi-diurnal constituent
M_4	shalow water overtides of the principal lunar constituent
MECO	Model of Estuaries and Coastal Oceans
Mf	lunar fortnight constituent
Mm	lunar monthly constituent
MN_4	lunarsolar synodic forthnight constituent and mean range of tide
MPA	Marine Protected Area
MS_4	shallow water quarter diurnal constituent
MSL	Mean Sea Level
N_2	larger lunar elliptic semi-diurnal constituent
$Na_6P_6O_{18}$	sodium hexametaphosphate
NAHRIM	National Hydraulic Research Institute Malaysia
O_1	lunar diurnal constituent
OCCAM	Global Ocean Model
P_1	rate of change mean longitude of solar perigee
PAST	PAleontological STatistical Software Package
PCA	Priority Conservation Area
PE	PolyEthylene
POM	Princeton Ocean Model

Q_1	large lunar elliptic diurnal constituent
RMSE	Root Mean Square Error
S_2	principal solar semi-diurnal constituent
SP	Standard Port
ST	Station
TMP	Tun Mustapha Park
TPXO	TOPEX/Poseidon and Jason
TSS	Total Suspended Sediment
USEPA	United Stated Environmental Protection Agency
WSG84	World Geodetic System 84
.bca	astronomical boundary condition
.bnd	open boundary
.dep	depth file
.enc	enclosure file
.grd	grid file
.kmz	keyhole markup language zipped file
.ldb	land boundary file
.png	portable network graphics file
.shp	geographic feature file
.trih	history file
.trim	map file

.xyz chemical file format

LIST OF SYMBOLS

°	degree
$	dollar
>	greater than
≥	greater than or equal to
<	less than
-	negative
%	percentage
±	plus minus
+	positive

LIST OF UNITS

°C	degree celsius
ϕ	phi
$\bar{x}$	mean
M_G	mean size
σ_G	sorting
Sk_G	skewness
K_G	kurtosis
m/s	metre per second
mg/L	miligram per litre
m/s^2	meter per second square
$m^3/s/m$	metre cubic per second per metre
kg/m^2	kilogram per metre square
d50	mean diameter
exp	exponential
g	gram
ln	$\log_{exponential}$
m	metre
mL	mililitre
mm	milimetre

min	minute
PPT	Part Per Thousand
PSU	Practical Salinity Unit
SD	standard deviation
µm	micrometre

LIST OF APPENDICES