

GEOCHEMISTRY OF SEDIMENT AND HEAVY METALS  
IN THE MAJOR ESTUARINE MANGROVE FOREST OF  
TERENGGANU, MALAYSIA

ONG MENG CHUAN

MASTER OF SCIENCE  
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**GEOCHEMISTRY OF SEDIMENT AND HEAVY METALS IN THE  
MAJOR ESTUARINE MANGROVE FOREST OF TERENGGANU,  
MALAYSIA**

DEDICATION

*To my family and my successors*

**ONG MENG CHUAN**

**Thesis Submitted in Fulfillment of the Requirement for the  
Degree of Master of Science in the Institute of Oceanography  
Kolej Universiti Sains dan Teknologi Malaysia**

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Abstract of thesis presented to the Senate of Kolej Universiti Sultan Ismail Terengganu  
Malaysia (KUSTEM) in fulfillment of the requirement for the degree of  
Master of Science

## GEOCHEMISTRY OF SEDIMENT AND HEAVY METALS IN THE MAJOR ESTUARINE MANGROVE FOREST OF TERENGGANU, MALAYSIA

ONG MENG CHUAN

JUNE 2006

Supervisor : Associate Professor Kamaruzzaman B. Yusoff, Ph.D.

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Associate Professor Kwam B. Yusoff, Ph.D.

Faculty : Institute of **DEDICATION**

*To my family and my sweetheart,*

*Who put up endless support on me*

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**JUNE 2006**

**Chairperson : Associate Professor Kamaruzzaman b. Yunus, Ph.D.**

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A geochemistry and sedimentology study had been conducted at major estuarine mangrove forest (Kemaman–Chukai, Kerteh, Paka, Dungun, Marang and Setiu) of Terengganu region. A total of seven transects with 100 sampling points were setup inside the mangrove forest. Two sampling were carried out to present the dry and wet season. The dry and wet season period sampling was represented by 10<sup>th</sup> to 20<sup>th</sup> May 2004 and 2<sup>nd</sup> to 8<sup>th</sup> January 2005, respectively. The heavy metal concentration, sediment characteristic, organic carbon content and sedimentation rate had been determined in this study.

Finer sediments dominate the mangrove forest during the dry season, while the coarser sediments dominate during the wet season. The coarser sediment occurred during the wet season may be due to the heavy rainfall and higher energy of water movement from the up stream, where the finer sediments were transported out to the sea. Meanwhile, the sediment mean size tends to be coarser towards the back

mangrove, maybe due to the bioturbation processes at the back mangrove. For sediment sorting, the sediment can be classified as very poorly sorted and poorly sorted for the both dry and wet seasons, respectively.

Heavy metal concentration in surficial sediment was analyzed by using the Inductively Coupled Plasma–Mass Spectrometry (ICP–MS) following with acid digestion using Teflon Bomb method. The average concentration for Al was  $2.55 \pm 0.97\%$ ; Pb ( $10.5 \pm 7.12 \mu\text{g/g dw}$ ); Co ( $7.81 \pm 2.80 \mu\text{g/g dw}$ ); Cu ( $31.1 \pm 16.5 \mu\text{g/g dw}$ ); Cd ( $0.43 \pm 0.27 \mu\text{g/g dw}$ ); Fe ( $0.78 \pm 0.29\%$ ); Mn ( $458 \pm 230 \mu\text{g/g dw}$ ); Zn  $20.8 \pm 13.3 \mu\text{g/g dw}$  and Cr ( $29.1 \pm 23.2 \mu\text{g/g dw}$ ), respectively.

In general, the concentration of Pb, Co, Cu, Cd, Fe, Mn, Zn and Cr show considerable variation spatially, largely appears to be controlled by natural processes except for Cd. This was supported by their enrichment factor (EF) which has values close to unity.  $I_{geo}$  index are classified in Class 0 and 1, practically uncontaminated to the uncontaminated to moderately contaminated class, which are considered to be dominantly terigenous in origin. The sources of heavy metal pollution in Terengganu mangrove maybe from mining activities along the river, nearby urban runoff, and agricultural runoff, uses of leaded gasoline in boat and ship and also emissions from automobiles consuming leaded petrol from vehicles using the major road (Kuala Terengganu–Kuantan).

The concentration of Cu, Fe and Mn show weak correlations with the particle size with  $r$ -value ranged from 0.05 and 0.19. Meanwhile, Pb, Co, Zn, Cd and Cr show a significant correlation with the particle size with  $r$ -value 0.22 to 0.51. In this study,

Cr, Mn and Zn show a high correlation with organic carbon with the  $r$ -value ranged from 0.38 to 0.41. Meanwhile Pb, Co, Cu, Cd and Fe show very negligible relationship with organic carbon with the weak  $r$ -value (0.06 to 0.18).

Sedimentation rates in Terengganu mangrove was determined by using the  $^{210}\text{Pb}$  method. Seven cores from each mangrove forest had been analyzed in order to calculate the sediment accretion. The sedimentation rate ranged from 0.88 cm/y to 1.12 cm/y, with mean of 1.00 cm/y. Results obtained were generally high compared with other studies in Malaysia. Higher accretion rate may be influenced primarily by fluvial processes and associated factors such as rainfall during monsoon season, suspended sediment load in the rivers, rates of relative river-level rise and sediment prevented by root of mangrove tree.

Abstrak tesis ini dikemukakan kepada Senat Kolej Universiti Sains dan Teknologi Malaysia (KUSTEM) sebagai memenuhi keperluan untuk ijazah Master Sains.

**GEOKIMIA BAGI SEDIMEN DAN LOGAM BERAT DI DALAM HUTAN  
PAYA BAKAU MUARA YANG UTAMA DI TERENGGANU,  
MALAYSIA**

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Satu kajian geokimia dan sedimentologi telah dijalankan di hutan paya muara yang utama (Kemaman–Chukai, Kerteh, Paka, Dungun, Marang dan Setiu) di negeri Terengganu. Sejumlah tujuh transek dengan 100 stesen persampelan telah ditetapkan di dalam hutan paya muara tersebut. Dua kali persampelan telah dijalankan untuk mewakili musim panas dan musim hujan. Penyampelan musim panas dan musim hujan masing–masing telah dijalankan pada 10<sup>hb</sup> hingga 20<sup>hb</sup> Mei 2004 dan 2<sup>hb</sup> hingga 8<sup>hb</sup> Januari 2005. Kepekatan logam berat, ciri–ciri sedimen, jumlah karbon organik dan kadar sedimentasi telah dianalisa dalam kajian ini.

Sedimen halus mendominasi kawasan kajian pada musim panas manakala sedimen kasar pula pada musim hujan. Sedimen kasar yang terdapat pada musim hujan mungkin hasil daripada taburan hujan yang tinggi dan arus sungai yang kuat, di mana sedimen halus dibawa keluar ke kawasan laut. Sementara itu, sedimen menjadi lebih kasar apabila semakin menjauhi dari gigi air atau tebing sungai,



mungkin kerana proses bioturbasi di kawasan belakang paya bakau. Untuk penyisihan sedimen, sedimen boleh diklasifikasikan sebagai penyisihan yang sangat tidak sempurna dan penyisihan yang lemah masing-masing untuk musim panas dan musim hujan.

Kepekatan logam berat di dalam sedimen permukaan diukur dengan menggunakan Inductively Coupled Plasma Mass Spectrometry (ICP-MS) setelah proses penghadaman asid menggunakan kaedah Teflon Bomb. Purata kepekatan untuk Al ialah  $2.55 \pm 0.97\%$ ; Pb ( $10.5 \pm 7.12 \mu\text{g/g bk}$ ); Co ( $7.81 \pm 2.80 \mu\text{g/g bk}$ ); Cu ( $31.1 \pm 16.5 \mu\text{g/g bk}$ ); Cd ( $0.43 \pm 0.27 \mu\text{g/g bk}$ ); Fe ( $0.78 \pm 0.29\%$ ); Mn ( $458 \pm 230 \mu\text{g/g bk}$ ); Zn  $20.8 \pm 13.3 \mu\text{g/g bk}$  and Cr ( $29.1 \pm 23.2 \mu\text{g/g bk}$ ).

Secara umumnya, kepekatan logam untuk Pb, Co, Cu, Cd, Fe, Mn, Zn dan Cr tersebar secara meluas dan wujud melalui proses semulajadi kecuali untuk logam Cd. Ini disokong dengan nilai faktor pengkayaan (EF) di mana nilainya menghampiri uniti.  $I_{geo}$  indeks pula diklasifikasikan di dalam kelas 0 dan 1 iaitu dari tahap tidak tercemar ke tahap sedikit tercemar dan boleh dianggap sebagai wujud secara semulajadi. Sumber pencemaran logam berat di hutan paya muara di Terengganu mungkin disebabkan oleh aktiviti perlombongan di sepanjang sungai, buangan dari kawasan petempatan manusia, buangan daripada aktiviti akuakultur, penggunaan minyak plumbum dalam bot dan kapal dan juga asap daripada kenderaan yang menggunakan petrol berplumbum di jalan utama (Kuala Terengganu–Kuantan).

Hubungan kolerasi di antara Cu, Fe dan Mn dengan saiz sedimen adalah sangat lemah dengan julat nilai  $r$  dari 0.05 hingga 0.19. Pb, Co, Zn, Cd dan Cr pula

mempunyai hubungan yang signifikan dengan saiz sedimen dengan nilai  $r$  di antara 0.22 hingga 0.51. Dalam kajian ini, Cr, Mn dan Zn mempunyai hubungan yang signifikan dengan karbon organik dengan julat nilai  $r$  dari 0.38 hingga 0.41. Pb, Co, Cu, Cd dan Fe pula menunjukkan hubungan yang lemah dan hampir boleh diabaikan dengan nilai  $r$  di antara 0.06 hingga 0.18.

Kadar sedimentasi di hutan paya laut Terengganu diukur melalui teknik pengenalpastian nuklid  $^{210}\text{Pb}$ . Tujuh sedimen teras dari setiap hutan paya muara telah dianalisa untuk mendapatkan kadar sedimentasi. Kadar sedimentasi ber julat dari 0.88 sm/tahun ke 1.12 sm/tahun, dengan nilai min 1.00 sm/tahun. Keputusan yang didapati adalah tinggi dibandingkan dengan kajian lain di Malaysia. Kadar sedimentasi yang tinggi mungkin disebabkan oleh proses fluvial dan dikaitkan dengan pelbagai faktor seperti taburan hujan ketika musim monsun, sedimen terampai di dalam sungai, proses pasang surut dan pemerangkapan sedimen oleh akar pokok bakau.