

HEAVY METAL SPECIATION AND MINERALOGY  
IN SEDIMENT OFF PAHANG COAST, MALAYSIA  
DURING PRE- AND POST-NORTH-EAST  
MONSOON SEASONS

CHOO KIM MING

MASTER OF SCIENCE  
INSTITUTE OF OCEANOGRAPHY  
UNIVERSITY MALAYSIA TERENGGANU

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This thesis is dedicated to my wonderful parents and my siblings who have supported me all the way since the beginning of my studies.

Also, this thesis is dedicated to my husband, who has been a great source of motivation and inspiration.

This thesis is dedicated to my dearest friends, who have been with me through good times and bad.

Finally, this thesis is dedicated to the Lord of the Universe, all people and every and everything that exists in this universe.

Thank you for all the unconditional love, guidance, and support that you have always given me, helping me to reach my goals with the confidence that I am capable of doing anything.

**CHOO KIM MING**

Thesis submitted in fulfilment of the Requirement for  
the Degree of Master Science in the Institute of  
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## DEDICATION

This thesis is dedicated to my wonderful parents and my siblings who have supported me all the way since the beginning of my studies.

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Finally, this thesis is dedicated to the lord of Buddha, all monks and nuns and laypersons those who practice in truth dharma.

Thank you for all the unconditional love, guidance, and support that you have always given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything. Thanks for everything....

Abstract of the thesis presented to the Senate of Universiti Malaysia Terengganu in fulfilment of the requirements for the Degree of Master of Science

**HEAVY METAL SPECIATION AND MINERALOGY IN SEDIMENT OFF THE PAHANG COAST, MALAYSIA DURING THE PRE- AND POST-NORTH-EAST MONSOON SEASONS**

**CHOO KIM MING**

**May 2009**

**Chairman** : **Professor Noor Azhar bin Shazili, Ph.D**  
**Members** : **Associate Professor Kamaruzzaman bin Yunus, Ph.D**  
: **Nor Antonina binti Abdullah, Ph.D**  
**Institute** : **Institute of Oceanography**

Twenty six surface sediment samples were collected from the near-shore area of Pahang coast, South China Sea during the pre- and post- Northeast monsoon periods. The concentrations of Cr, Fe, Mn, Ni, Pb and Zn of five chemical fractions in the sediment were determined using the fractionation scheme of Tessier *et al.* (1979). The mean concentrations of total metals studied were considered low compared to crustal value and regional studies.

Total Al, Cr, Fe, Mn, Ni, Pb and Zn concentrations were enriched in Transects 1 (Station 1), 5, 6 and in the southern sector of the study area especially in the inshore and near-shore stations. The Fe-Mn oxide fraction was the dominant bio-available fraction of the four bio-available fractions. Cr, Ni, Pb and Zn were mostly found in the residual fraction while for Fe and Mn in the Fe-Mn oxide phase in pre NE monsoon sediments.

All metals studied have a significant difference ( $p < 0.05$ , Tukey HSD test).

In post NE monsoon sediments, Cr, Ni and Pb were mostly bound in the residual fraction and Zn in organic matter fraction while Fe and Mn in the Fe-Mn oxide fraction. The monsoon was clearly seen to have some effect on metal distribution within the chemical fractions, because the proportion of metals increased in the bio-available fraction in sediments collected after the North-east monsoon. The increases were found for Cr, Fe, Ni, Pb and Zn in exchangeable fraction; carbonate Fe, Cr, Fe, Mn, Ni, Pb and Zn in Fe-Mn oxide fraction; Cr, Ni, Pb and Zn in organic matter fraction and for residual Cr, Fe, Mn and Ni. However after the NE monsoon, a large reduction in enrichment factor (EF) values were found for Pb and Zn in the sediment throughout the study area suggesting that these metals were diluted and/or redistributed within the sedimentary environment. It is thought that input of fresh clean sediment from monsoon run-off via Pahang, Kuantan, Bebar, Merchong and Rompin rivers dilutes the metal contents in the Pahang coastal sediments. Alternatively or together with dilution, the sediments are redistributed and mixed resulting in overall dilution of metal concentrations.

All total metals studied were positively and strongly correlated with other metals in both pre- and post- NE monsoon sediments. This indicates the common and natural origin of metals in this study area. There was a significant ( $p < 0.05$ ) difference between metal concentrations comparing two sampling periods for total Al (Wilcoxon signed rank test), Fe and Mn (Paired  $t$ -test).

All metals studied have a significant difference ( $p < 0.05$ , Turkey HSD test and Mann-Whitney test) within the relationship in most of the metal fractionations in both pre- and post- NE monsoon sediments, especially exchangeable-Fe-Mn oxide, carbonate-Fe-Mn oxide and carbonate-residual. This also suggests that these chemical fractions of the metal studied are possibly mobilized in Pahang near-shore sediment.

The mineral analysis comprised of X-ray diffraction (XRD) analysis, Quantitative mineral estimation (QME) and petrography microscope analysis. Overall, minerals found in this study were dominated by quartz (light mineral), followed by kaolinite, feldspars, sepiolite, illites, carbonate mineral (calcite), traces amounts of clay mineral (gibbsite) and heavy minerals (andalusite, amphibole, ilmenite, leucoxene, Iron oxide, magnetite, olivine, siderite, tourmaline and zircon). There were only slight differences in mineral composition between the samples analysed.

Abstrak tesis yang dikemukakan kepada Senat of Universiti Malaysia Terengganu sebagai memenuhi syarat mendapat Ijazah Sarjana Sains.

**PENENTUAN SPESIS LOGAM BERAT DAN MINERALOGI DI SEDIMEN  
DI PERAIRAN PAHANG, MALAYSIA, SEBELUM- DAN SELEPAS-  
MONSUN TIMUR LAUT**

**CHOO KIM MING**

**Mei 2009**

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**Members** : **Associate Profesor Kamaruzzaman bin Yunus, Ph.D**  
: **Nor Antonina binti Abdullah, Ph.D**  
**Institute** : **Institut Oseanografi**

Dua puluh enam sedimen permukaan telah diambil dari sepanjang kawasan pesisir-dekat Pahang, Laut China Selatan sebelum- dan selepas- musim monsun timur laut. Kepekatan Cr, Fe, Mn, Ni, Pb dan Zn bagi lima fraksi kimia telah ditentukan dengan menggunakan skema Tessier *et al.* (1979). Kepekatan min bagi jumlah logam dikaji dianggap rendah berbanding dengan nilai kerak bumi dan kajian serantaun.

Kepekatan Al, Cr, Fe, Mn, Ni, Pb dan Zn jumlah adalah tinggi dalam Transek 1 (Stesen 1), 5, 6 dan dalam sektor selatan kawasan kajian terutama sekali di tepi pantai dan dekat pesisir. Fraksi oksida Fe-Mn adalah fraksi dominan bio-mudahalih bagi empat fraksi bio-mudahalih yang dikaji. Sementara itu, kebanyakan Cr, Ni, Pb dan Zn didapati di dalam di fraksi sisa manakala untuk Fe dan Mn dalam fraksi oksida Fe-Mn dalam sedimen sebelum- monsun timur laut.

Dalam sedimen selepas- monsun timur laut, kebanyakan Cr, Ni dan Pb adalah terikat dengan fraksi sisa dan Zn diikat dengan fraksi bahan organik manakala Fe dan Mn pula dalam fraksi oksida Fe-Mn. Angin monsun ternyata mempengaruhi agihan logam dalam fraksi kimia kepekatan logam yang bertambah dalam fraksi bio-mudahalih dalam sedimen yang diambil selepas- monsun timur laut. Fraksi-fraksi bio-mudahalih termasuk fraksi boleh ditukar adalah terikat dengan Cr, Fe, Ni, Pb dan Zn; fraksi karbonat untuk Fe, fraksi oksida Fe-Mn untuk Cr, Fe, Mn, Ni, Pb dan Zn; fraksi bahan organik untuk Cr, Ni, Pb dan Zn; fraksi sisa untuk Cr, Fe, Mn dan Ni. Bagaimanapun, selepas- monsun timur laut, nilai Faktor Perkayaan (EF) didapati menurun dengan ketara bagi Pb dan Zn, menunjukkan logam-logam ini dicairkan dan/atau disebarkan di dalam persekitaran sedimen. Ia juga dikaitkan dengan sedimen bersih baru masuk daripada air yang dibawa oleh angin monsun melalui sungai-sungai Pahang, Kuantan, Bebar, Merchong dan Rompin yang mencairkan kandungan-kandungan logam di sedimen persisir-dekat Pahang. Selain itu, atau bersama dengan penciaran, sedimen disebarkan semula dan bercampur, menghasilkan pencairan atau penurunan kepekatan logam.

Kesemua logam jumlah dikaji berkorelasi positif dan berhubung kait kuat dengan semua logam lain dalam sedimen bagi kedua-dua musim monsun tersebut. Ini menunjukkan logam adalah berasal dari alam semulajadi. Terdapat perbezaan ketara ( $p < 0.05$ ) antara kepekatan logam membandingkan dua jangka masa pensampelan bagi Al jumlah (Ujian pangkat bertanda Wilcoxon), Fe dan Mn (ujian-t berpasangan).

Semua logam dikaji mempunyai perbezaan nyata ( $p < 0.05$ , ujian Turkey HSD dan ujian Mann-Whitney) dalam hubungan dengan kebanyakan fraksi-fraksi logam dalam sedimen sebelum- dan selepas- monsun timur laut, terutamanya fraksi mudahalih-oksida Fe-Mn, karbonat-oksida Fe-Mn dan karbonat-fraksi sisa. Ini juga mencadangkan fraksi-fraksi kimia bagi logam adalah mungkin dikerah dalam sedimen pesisir-dekat Pahang.

Analisis mineral adalah termasuk analisis pembelauan sinar-X (XRD), Anggaran Kuantitatif Mineral (QME) dan analisis mikroskop petrografi. Keseluruhannya, mineral yang didapati dalam kajian didominasi oleh kuarza (mineral ringan), dan seterusnya kaolinit, feldspar, sepiolit, illites, mineral karbonat (kalsit). Selain daripada itu, sedikit mineral lempung (gibsit) dan mineral berat (andalusit, amfibol, ilmenit, leukoksen, oksida ferum, magnetit, olivin, siderit, turmalin dan zirkon). Hanya terdapat sedikit perbezaan dalam kandungan mineral di antara sedimen yang dianalisis sebelum- dan selepas- monsun timur laut.