

MONSOON EFFECTS ON THE GEOCHEMICAL OF SURFACE
SEDIMENT IN THE NEARSHORE AREA OFF
TERENGGANU, MALAYSIA

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**MONSOON EFFECTS ON THE GEOCHEMICAL OF SURFACE SEDIMENT IN
THE NEARSHORE AREA OFF TERENGGANU, MALAYSIA**

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Dedication

Award of thesis presented to the Council of Sains Malaysia Terengganu in fulfillment of the requirement for the Degree of Master of Science.

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July 2007

Chairperson : Associate Professor Kamaruzzaman b. Yusoff, Ph.D

Members : Professor Noor Azhar b. Mahmud Sharih, Ph.D
Associate Professor Roslan b. Yusoff, Ph.D

Institution : Institute of Geology

This thesis investigates the geochemical characteristics of the surface sediments of Terengganu nearshore area during the pre- and post-monsoon seasons and redox condition. Sampling activities were carried out twice in two years, in September 2002 and April 2003. The sampling covered an area approximately 750 nautical miles wide. Sampling points were set on a seven transects which consisted of seven points each. For duration, sediment grain size, organic carbon, heavy metal and also sedimentation rates.

Generally the coastal area sediments of the Terengganu nearshore area are composed of silty sand sediments. Coarse sediments is also located in the area nearby islands, i.e. Pulau Tioman, Pulau Redang, Pulau Besang and Pulau Kapas islands. With respect to the seasons, it is observed that the average post-monsoon sediments are very fine sized, and are classified as poorly sorted and non-symmetrical. During the pre-monsoon season, however, the study area was dominated by very coarse silt, and the sediment structure type was also classified as poorly sorted and non-symmetrical.

Abstract of thesis presented to the Senate of Universiti Sains Malaysia Terengganu in fulfillment of the requirement for the Degree of Master of Science.

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This thesis investigates the geochemical characteristics of the surface sediments of Terengganu nearshore area during the pre- and post-monsoon seasons and sedimentation rate. Sampling activities were carried out twice in two years, in September 2002 and April 2003. The samplings covered an area approximately 750 nautical square miles. Sampling points were setup in seven transects which consisted of seven points each. For this work, sediment grain size, organic carbon, heavy metal and also sedimentation rates.

Generally the coastal area sediments of the Terengganu nearshore area are coarser than offshore sediments. Coarse sediment is also located in the areas nearby islands, i.e. Perhentian, Redang, Bidong and Kapas Islands. With respect to the seasons, it is observed that the average post-monsoon sediments are very fine sand, and are classified as poorly sorted and near symmetrical. During the pre-monsoon season, however, the study area was dominated by very coarse silt, and the sediment structure type was also classified as poorly sorted and near symmetrical.

In this study, the concentrations of heavy metals, such as Al, Fe, Mn, Zn, Cu, Co, Cd and Pb were measured from sediment samples obtained from the sampling points of the Terengganu nearshore. The average concentrations of heavy metals during pre-monsoon season were 6.30 ± 1.74 % (Al); 4.17 ± 0.76 % (Fe); 536.96 ± 99.48 $\mu\text{g/g}$ (Mn); 38.97 ± 10.22 $\mu\text{g/g}$ (Zn); 26.75 ± 6.18 $\mu\text{g/g}$ (Cu); 14.25 ± 3.14 $\mu\text{g/g}$ (Co); 0.59 ± 0.04 $\mu\text{g/g}$ (Cd) and 28.53 ± 9.10 $\mu\text{g/g}$ (Pb). The average concentration of heavy metals during post-monsoon season were 5.64 ± 1.73 % (Al); 3.97 ± 0.78 % (Fe); 475.46 ± 95.71 $\mu\text{g/g}$ (Mn); 34.41 ± 6.19 $\mu\text{g/g}$ (Zn); 23.82 ± 6.24 $\mu\text{g/g}$ (Cu); 13.36 ± 3.03 $\mu\text{g/g}$ (Co); 0.59 ± 0.03 $\mu\text{g/g}$ (Cd) and 26.50 ± 8.70 $\mu\text{g/g}$ (Pb). The concentrations of most metals were lower during post-monsoon season. Generally, most heavy metals show a weak correlation with sediment grain size and C_{org} during both seasons.

In order to verify the pollution status of heavy metals in the study area, Enrichment factors (EF), the geoaccumulation index (I_{geo}) and Normalization have been applied. The EF' of studied heavy metals were studied using the following order of enrichment phase: $\text{Cd} > \text{Pb} > \text{Fe} > \text{Al} > \text{Co} > \text{Cu} > \text{Mn} > \text{Zn}$. The average EF factor, which obtained close to one, indicates that there is no pollution risk and from natural sources in origin. However, the study area was moderately enriched with Pb. Meanwhile, there were no pollutant effects in the study area with regard to Al, Cu, Zn, Mn, Co, Cd and Fe, which show averages of $I_{\text{geo}} < 1$, corresponding to the uncontaminated class. However, the Pb index was down to the unpolluted-to-moderately polluted classes I_{geo} possibly due to the river run-off which contains high concentrations of Pb pollutant. A normalization method

shows certain sampling points in the study area were influenced by heavy metals from anthropogenic sources.

The nuclide method of ^{210}Pb was applied to determine the sedimentation rate of sediment in the Terengganu nearshore area. The sedimentation rate of the Terengganu nearshore area was $0.21 \text{ cm year}^{-1}$, respectively. The sedimentation rate in the South China Sea mainly depends on the seasonal current movement, particularly the NE monsoon and SE monsoons.

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**KESAN-KESAN MONSUN TERHADAP CIRI-CIRI GEOKIMIA BAGI
SEDIMEN PERMUKAAN DI KAWASAN PERSISIR PERAIRAN, MALAYSIA**

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Kajian tesis ini adalah berkaitan ciri-ciri geokimia sedimen permukaan di kawasan persisir Terengganu ketika musim pra dan pasca monsoon serta kadar pendedapan sedimen. Aktiviti penyampelan dilakukan sebanyak dua kali dalam tempoh dua tahun, iaitu pada bulan September 2002 dan April 2003. Penyampelan meliputi kawasan seluas lebih-kurang 750 batu nautika persegi. Stesen penyampelan telah di bentuk di dalam tujuh transek dengan mengandungi tujuh stesen setiap satunya. Bagi tugasan ini, saiz butiran sedimen, karbon organik, logam serta kadar pendedapan sedimen telah dititikberatkan.

Secara umumnya, sedimen di kawasan berhampiran pantai di perairan Terengganu adalah lebih kasar berbanding sedimen laut lepas. Sedimen yang kasar turut di jumpai di kawasan berhampiran pulau-pulau seperti Pulau Perhentian, Redang, Bidong dan Kapas.

Melihat kepada aspek musim, didapati purata sediment musim pasca monson adalah pasir sangat halus dan boleh diklasifikasikan sebagai poorly sorted dan hampir simetri. Ketika musim pra monson, kawasan kajian adalah didominasi oleh koladak sangat kasar, tetapi struktur sedimen juga adalah poorly sorted dan hampir simetri.

Dalam kajian ini, beberapa logam berat seperti Al, Fe, Mn, Zn, Cu, Co, Cd dan Pb diukur daripada sampel sedimen yang diperolehi daripada kawasan persisir Terengganu. Purata kepekatan logam-logam berat tersebut ketika musim pra monson adalah, 6.30 ± 1.74 % (Al); 4.17 ± 0.76 % (Fe); 536.96 ± 99.48 $\mu\text{g/g}$ (Mn); 38.97 ± 10.22 $\mu\text{g/g}$ (Zn); 26.75 ± 6.18 $\mu\text{g/g}$ (Cu); 14.25 ± 3.14 $\mu\text{g/g}$ (Co); 0.59 ± 0.04 $\mu\text{g/g}$ (Cd) dan 28.53 ± 9.10 $\mu\text{g/g}$ (Pb). Manakala ketika musim pasca monson pula kepekatan logam-logam berat tersebut adalah, 5.64 ± 1.73 % (Al); 3.97 ± 0.78 % (Fe); 475.46 ± 95.71 $\mu\text{g/g}$ (Mn); 34.41 ± 6.19 $\mu\text{g/g}$ (Zn); 23.82 ± 6.24 $\mu\text{g/g}$ (Cu); 13.36 ± 3.03 $\mu\text{g/g}$ (Co); 0.59 ± 0.03 $\mu\text{g/g}$ (Cd) dan 26.50 ± 8.70 $\mu\text{g/g}$ (Pb). Kepekatan kebanyakan logam adalah rendah ketika musim pasca monsun. Secara umumnya, kebanyakan logam berat menunjukkan hubungan korelasi yang lemah dengan saiz butiran sedimen dan karbon organik dalam kedua-dua musim.

Dalam menentukan status pencemaran bagi logam-logam berat yang di kaji di kawasan kajian, Faktor Pengkayaan (EF), Indeks geopemendapan (I_{geo}) dan normalisasi telah digunakan. Nilai EF bagi logam-logam tersebut adalah mengikut urutan fasa pengkayaan berikut: Cd > Pb > Fe > Al > Co > Cu > Mn > Zn. Purata EF yang diperolehi adalah menghampiri satu, menunjukkan kawasan kajian tidak mempunyai risiko pencemaran and terhasil daripada sumber-sumber semulajadi. Walaubagaimanapun sedimen

permukaan di kawasan kajian didapati telah di perkaya oleh Pb tersebut dalam fasa pengkayaan yang sederhana. Manakala dengan menggunakan I_{geo} menunjukkan tiada kesan di kawasan kajian bagi logam Al, Cu, Zn, Mn, Co, Cd and Fe ($I_{geo} < 1$), merujuk kepada kelas tidak tercemar. Tetapi indek Pb pula adalah di antara tidak tercemar kepada sederhana tercemar, kemungkinan disebabkan oleh kemasukkan aliran air sungai yang mengandungi kepekatan pencemar Pb yang tinggi. Kaedah Normalisasi mendedahkan beberapa kawasan penyampelan telah dipengaruhi oleh beberapa logam berat yang di kaji daripada sumber-sumber antropogenik.

Kaedah nuklid ^{210}Pb telah digunakan untuk penentuan kadar pemendapan sedimen di kawasan persisir Terengganu. Berdasarkan kepada kajian didapati kadar pemendapan sedimen di kawasan kajian adalah 0.21 sm thn^{-1} . Pengaruh kadar pemendapan di Laut China Selatan adalah bergantung kepada pergerakan arus bermusim, monsun NE dan monsun SE. Kadar pemendapan sedimen berkemungkinan lebih signifikan ketika monsun NE yang meningkatkan kemasukan air sungai ke kawasan pantai.