Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

**PREDICTION OF TOTAL SUSPENDED SEDIMENTS
IN PENANG WATERS
USING REMOTE SENSING**

By

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July 2004

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Total suspended sediments (TSS) are one of the main causes of pollution in the country's coastal areas. Land-based loaded and seabed re-suspension are two main sources of TSS in coastal and estuary areas. In this study, remote sensing techniques were used to predict TSS concentrations.

Landsat-5 TM satellite imagery was used simultaneously with ground-truth data collected on 27th May 2000 in the Penang Straits. Various image processing steps such as geometric correction, radiometric correction and atmospheric correction were carried out in this study. Initially, digital number (DN) of imagery was corrected and converted into reflectance values for algorithm development. Subsequently

combinations of various radiometric correction methods were used in this study to reduce the errors from various sources prior to statistical analysis. Data generated from corrected satellite imagery and TSS concentrations measured from field sampling were compared and tested using statistical analysis. Only the best-fit algorithm developed in this study was selected to predict the TSS concentrations from satellite imagery. Out of the six algorithms derived, Algorithm 6 showed the best correlation with the ground-truth data (R^2 value of 0.9755 and RMSE value of 4.0107).

The developed algorithm was then applied to predict the TSS concentrations on historical Landsat imagery acquired on 1st February 1993. The historical satellite image was normalized and converted to reflectance for the biophysical study. Besides the derived algorithm, models suggested by other researchers were tested in this study. However, the Algorithm 6 showed the best results in predicting TSS concentration for the Penang waters. The predicted TSS concentrations distribution maps were generated and compared with the GIS platform.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

**PENGANGGARAN ENDAPAN TERAMPAI KESELURUHAN
DI SEKITAR PERAIRAN PULAU PINANG
DENGAN PENDERIAAN JARAK JAUH**

Oleh

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Endapan terampai keseluruhan (*total suspended sediments* atau *TSS*)
merupakan salah satu punca pencemaran yang sering ditemui di alam
marin di negara ini. Penghasilan endapan terampai keseluruhan dari darat
dan dasar laut adalah dua sumber utama di kawasan laut dan muara.
Dalam kajian ini, teknik penderiaan jarak jauh telah digunakan untuk
menganggar kepekatan kandungan endapan terampai keseluruhan.

Imej satelit Landsat-5 TM digunakan serentak dengan data kajian
lapangan yang telah dijalankan pada 27hb. Mei 2000 di perairan negeri
Pulau Pinang dalam kajian ini. Pelbagai langkah pemprosesan data seperti
pembentulan geometri, pembetulan radiometrik dan pembetulan
atmosfera telah dilakukan ke atas imej satelit itu. Nombor digital (*digital*

number atau *DN*) telah diperbetulkan dan ditukarkan nilainya menjadi *reflectance* untuk pembentukan algoritma. Kombinasi pelbagai cara pembetulan radiometrik telah digunakan dalam kajian ini untuk mengurangkan ralat yang terhasil daripada pelbagai sumber sebelum analisis statistik dijalankan.

Data daripada hasil pemprosesan imej satelit dan kerja lapangan telah dibandingkan serta dianalisis secara statistik. Hanya algoritma yang terbaik sahaja dipilih dan digunakan untuk meramal kepekatan endapan terampai keseluruhan daripada imej satelit. Daripada enam algoritma yang dihasilkan, Algoritma ke-6 menunjukkan korelasi yang paling tinggi dengan data yang dikumpulkan semasa kerja lapangan (nilai R^2 mencatatkan 0.9755 and nilai RMSE mencatatkan 4.0107).

Algoritma yang terhasil itu kemudiannya digunakan untuk meramal kepekatan endapan terampai keseluruhan dari imej satelit Landsat yang diperolehi pada 1hb. Februari 1993. Imej tersebut seterusnya diselaraskan dan ditukar nilai pada *reflectance* untuk kajian biofizikal. Selain daripada algoritma yang dihasilkan, model yang dicadangkan oleh penyelidik lain turut dikaji dalam kajian ini. Bagaimanapun, Algoritma 6 menunjukkan keputusan yang terbaik untuk meramal kepekatan endapan terampai keseluruhan di perairan negeri Pulau Pinang. Peta-peta ramalan kepekatan TSS dihasilkan dan dibandingkan dengan teknik GIS.

ACKNOWLEDGEMENTS

I certify that an Examination Committee met on 9th July 2004 to conduct the final examination of Tan Sek Aun on his Master Degree thesis entitled "Total Suspended Sediments Prediction of The Penang Waters Using Remote Sensing Technique" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1980. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for
quotations and citations which have been duly acknowledged. I also
declare that it has not been previously or concurrently submitted for any
other degree at UPM or other institutions.

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TAN SEK AUN

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