

SPATIAL AND TEMPORAL VARIATIONS OF
NUTRIENTS IN SETIU-MERANG COASTAL RIVER
AND ITS ESTUARINE LAGOON, TERENGGANU,
MALAYSIA

NICHOLAS NG CHIA WEI

MASTER OF SCIENCE

2018

NICHOLAS
NG CHIA WEI

MASTER OF SCIENCE
UNIVERSITI MALAYSIA TERENGGANU

JANUARY 2018

SPATIAL AND TEMPORAL VARIATIONS OF
NUTRIENTS IN SETIU-MERANG COASTAL RIVER
AND ITS ESTUARINE LAGOON, TERENGGANU,
MALAYSIA

NICHOLAS
NG CHIA WEI

Thesis Submitted in Fulfilment of the Requirements for
the Degree of Master of Science in the School of Marine
and Environmental Sciences
Universiti Malaysia Terengganu

JANUARY 2018

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu
in fulfilment of the requirement for the degree of Master of Science

**SPATIAL AND TEMPORAL VARIATIONS OF NUTRIENTS IN SETIU-
MERANG COASTAL RIVER AND ITS ESTUARINE LAGOON,
TERENGGANU, MALAYSIA**

NICHOLAS NG CHIA WEI

January 2018

Main supervisor : Poh Seng Chee, Ph.D.

School : School of Marine and Environmental Sciences

Setiu-Bari-Chalok-Merang (Setiu-Merang) coastal river and its estuarine lagoon (Setiu Wetlands Lagoon-SWL) are located on the east coast of Peninsular Malaysia, is an important coastal zone subjected to increased anthropogenic influences. The rivers and lagoon in Setiu play an important role in local social economic development. However, these waterways had encountered huge pollution challenges from various anthropogenic inputs. Its pollution sources, fate and transport in both surface water and groundwater have not yet been investigated in detail.

Hence, the primary objective of this thesis is to study the spatio-temporal distribution trends of selected nutrients species ($\text{NH}_4^+\text{-N}$, $\text{NO}_3^-\text{-N}$, $\text{NO}_2^-\text{-N}$, $\text{PO}_4^{3-}\text{-P}$) in both Setiu-Merang Rivers and lagoon and its relationship in association with land use changes, geomorphological alteration and seasonality. In addition, a study on the surface water-groundwater interaction was conducted in one of tributaries, Ular River to evaluate the magnitude of nutrient input through the groundwater discharge and its effect to the surface water quality in SWL.

This thesis provides a new set of nutrients data on surface water quality in association to its potential sources. The average concentration of ammonium, nitrate, phosphate and nitrite in Merang-Bari-Chalok-Setiu river complex and SWL were 21.1 μM , 5.87 μM , 0.11 μM and below detection limit, respectively. In combined with the observations on the spatial distribution patterns of nutrients, Chalok River in dry and transition periods and Setiu River in the wet period were found to be significant contributors of nitrate concentrations to the study area. Higher phosphate level was linked to the oil palm plantation adjacent to SWL while temporarily closing of the lagoon inlet in the wet season has also found to bring forth notable effects such as fecal pollution to the water quality in SWL. In addition, the uses of standard limit such as MMWQCS on certain selected parameters to represent and describe the watershed's quality and condition were found to be useful. This practice could reduce dependency of the coastal manager on water quality indices (e.g. WQI) which are represented by a narrow range of water quality parameters.

In the study, long-term trend (temporal) data analysis reveals that large-scale conversion of forest land to other land use purposes such as shrimp farm adjacent to the Chalok River had drastically elevated TSS value in SWL in year 2010 while the newly built farm has also increased the ammonium loading to the estuary. Furthermore, high $\text{PO}_4^{3-}\text{-P}$ level in the lagoon during 2005 was linked to the mass expansion and fertilizer application activities in the newly cultivated oil palm plantation around SWL.

This study has also discovered correlation between elevated radon concentrations and the nitrogen species (e.g. ammonium) in Ular River. The finding indicates

positive groundwater discharge activities in the tributary and its contribution to SWL. The radon mass balance model shows that daily groundwater discharge rate in Ular River made up of the value of $6649 \text{ m}^3\text{day}^{-1}$, which consists of 32.6 % of the total tributary discharge and this groundwater discharge has contributed to about 288 molday^{-1} , 123 molday^{-1} and 0.75 molday^{-1} of ammonium-nitrogen, nitrate-nitrogen and nitrite-nitrogen, respectively into the Ular River. Magnitude of the groundwater-derived nutrient fluxes from the river to the lagoon can be estimated if the lagoon volumetric flow and nutrient fluxes data could be accessed. There are large portions of unaccounted groundwater-derived nutrients inputs from the other tributaries and from the lagoon itself which are yet to be studied as part of the nutrient budget in SWL.

In summary, this thesis has provided new nutrient dataset for Setiu-Merang coastal river and its estuarine lagoon, SWL. The collection and interpretation of the groundwater chemistry data has also provides new knowledge on surface-groundwater chemistry interactions within the study region and highlighted the importance of including groundwater discharge as a significant component in the coastal nutrient budgets.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu
sebagai memenuhi keperluan untuk ijazah Sarjana Sains

**VARIASI SPATIAL DAN TEMPORAL NUTRIEN DI SUNGAI SISIRAN
LAUT DAN LUGUNA ESTUARI SETIU-MERANG, TERENGGANU,
TERENGGANU, MALAYSIA**

NICHOLAS NG CHIA WEI

Januari 2018

Penyelia Utama : Poh Seng Chee, Ph.D.

Pusat Pengajian : Pusat Pengajian Sains Marin dan Sekitaran

Sungai sisiran laut Setiu-Bari-Chalok-Merang (Setiu-Merang) dan laguna estuarinya (Laguna Tanah Bencah Setiu-SWL) terletak di pantai timur Semenanjung Malaysia. Ia merupakan zon pesisir penting yang terdedah kepada peningkatan pengaruh antropogenik. Sungai dan laguna di Setiu memainkan peranan penting dalam pembangunan ekonomi sosial tempatan. Walaupun begitu, saluran air tersebut menghadapi cabaran pencemaran besar dari pelbagai input antropogenik. Namun, sumber, nasib dan pengangkutan pencemarnya di permukaan air dan air bawah tanah belum disiasat secara terperinci.

Objektif utama tesis ini adalah untuk mengkaji trend pengedaran spatial dan temporal spesies nutrien terpilih ($\text{NH}_4^+\text{-N}$, $\text{NO}_3^-\text{-N}$, $\text{NO}_2^-\text{-N}$, $\text{PO}_4^{3-}\text{-P}$) di kedua-dua Sungai Setiu-Merang dan laguna Setiu dan hubungannya dengan perubahan penggunaan tanah, geomorfologi dan musim. Selain itu, kajian mengenai interaksi air bawah tanah dan air permukaan telah dijalankan di Sungai Ular untuk menilai magnitud input nutrien melalui pelepasan air bawah tanah dan kesannya kepada kualiti air permukaan di SWL.

Tesis ini menyediakan set data nutrien baru pada kualiti air permukaan bersekutu dengan sumber potensinya. Kepekatan purata ammonium, nitrat dan fosfat di kompleks sungai Merang-Bari-Chalok-Setiu dan SWL adalah 21.1 μM , 5.87 μM dan 0.11 μM , dan nitrit berada di bawah had kesanan instrumentasi. Digabungkan dengan pemerhatian terhadap corak pengedaran spatial nutrien, Sungai Chalok dalam tempoh kering dan peralihan musim, dan Sungai Setiu dalam tempoh basah adalah didapati sebagai penyumbang ammonium utama ke kawasan kajian. Tahap fosfat yang lebih tinggi dikaitkan dengan perladangan kelapa sawit bersebelahan dengan SWL dan penutupan sementara muara sungai pada musim hujan juga didapati membawa kesan yang ketara seperti pencemaran koliform tinja kepada kualiti air di SWL. Di samping itu, penggunaan had piawai seperti MMWQCS pada parameter tertentu yang dipilih untuk mewakili dan menggambarkan kualiti dan keadaan tadahan air didapati berguna. Amalan ini boleh mengurangkan kebergantungan pengurus pantai terhadap indeks kualiti air (contohnya: WQI) yang diwakili oleh parameter kualiti air yang terhad.

Dalam kajian ini, analisa data berjangka panjang (temporal) menunjukkan bahawa penukaran tanah hutan secara besar-besaran kepada penggunaan tanah yang lain seperti ladang udang bersebelahan dengan Sungai Chalok telah meningkatkan nilai TSS secara drastik di SWL pada tahun 2010 manakala ladang yang baru dibina tersebut juga didapati meningkatkan pemuatan ammonium ke muara sungai sebelah. Selain itu, tahap PO_4^{3-}P yang tinggi di laguna pada tahun 2005 dikaitkan dengan aktiviti pengembangan dan pembajaan di ladang kelapa sawit yang baru ditanam di sekitar SWL.

Kajian tersebut juga telah menemui korelasi antara kepekatan radon tinggi dengan spesies nitrogen, contohnya ammonium di Sungai Ular. Hasil kajian menunjukkan aktiviti pelepasan air bawah tanah di anak sungai tersebut dan sumbangannya kepada SWL. Model imbangan massa radon menunjukkan bahawa kadar pelepasan air bawah tanah di Sungai Ular terdiri daripada nilai $6649 \text{ m}^3\text{day}^{-1}$, merupakan 32.6 % daripada jumlah pelepasan air sungai tersebut dan pelepasan air bawah tanah ini telah menyumbang kepada kira-kira 288 molday^{-1} , 123 molday^{-1} dan 0.75 molday^{-1} ammonium-nitrogen, nitrat-nitrogen dan nitrit-nitrogen ke Sungai Ular. Magnitud sumbangan nutrien yang diperolehi dari air bawah tanah ke laguna dapat dianggar jikalau aliran volumetrik laguna dan data sumbangan nutriennya dapat diakses. Terdapat banyak sumbangan nutrien yang diperolehi dari saluran air yang tidak kelihatan dan anak-anak sungai lain termasuk dari laguna sendiri yang masih belum dikaji. Kajian tersebut penting untuk dijadikan sebagai sebahagian daripada bajet nutrien kepada SWL.

Secara ringkasnya, tesis ini telah menyediakan dataset nutrien baru untuk sungai sisiran laut Setiu-Merang dan laguna estuarinya, SWL. Pengumpulan dan tafsiran data kimia air bawah tanah juga membekalkan pengetahuan baharu mengenai interaksi kimia air permukaan dengan air bawah tanah di dalam kawasan kajian dan menekankan betapa pentingnya memasuki pelepasan air bawah tanah sebagai komponen penting dalam bajet nutrien di zon pesisir laut.