

**DISTRIBUTION AND FLUXES OF DISSOLVED
CARBON, NITROGEN AND PHOSPHORUS
IN TERENGGANU RIVER ESTUARY**

JONG KHIAM JAN

**MASTER OF SCIENCE
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UNIVERSITI MALAYSIA TERENGGANU (UMT)
21030 KUALA TERENGGANU

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By
JONG KHIAM JAN

September 2002

Chairman : Prof. Dr. Law Ah Thiam, Ph.D.

Faculty : Science and Technology
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The nutrients (carbon, nitrogen and phosphorus), BOD₅, total alkalinity, total sulfide bacteria and hydrological properties of Terengganu River estuary, South China Sea were studied monthly from September 1999 to September 2000. A total of 14 sampling stations were established in the study area. The samples were taken at the surface, mid-depth and bottom waters at each sampling station. The study area was searched eleven times.

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

DISTRIBUTION AND FLUXES OF DISSOLVED CARBON, NITROGEN AND PHOSPHORUS IN TERENGGANU RIVER ESTUARY

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The nutrients (carbon, nitrogen and phosphorus), BOD₅, total alkalinity, fecal coliform bacteria and hydrological properties of Terengganu River estuary, South China Sea were studied monthly from September 1999 to September 2000. A total of 14 sampling stations were established in the study area. The sample was taken at the surface, mid-depth and bottom waters at each sampling station. The study area was sampled eleven times.

Terengganu River estuary is an unique estuary and the seawater intrusion is a seasonal event. Monsoon rains will dilute the nutrient and sewage levels in the estuary. The residence times calculated ranged between 12.22 hours and 15.63 hours. Tidal condition has minimal influence on the nutrient and sewage

distributions in the estuary during the NE monsoon period. The main source of water in the estuary is from the rivers and precipitation.

Generally, the water quality met the water quality criteria for aquaculture. The temperature and pH showed the normal estuary distribution. All parameters showed higher concentrations during the SW than the NE monsoon season except the nitrate, which was vice versa. All nutrients except nitrite and phosphorus showed significant difference ($p < 0.05$) with water depths and monsoons.

Low levels of nitrite (NO_2^-) and orthophosphate (PO_4^{3-}) were detected with ranges between 0.01 and 0.76 $\mu\text{g-at N/L}$ and, 0.04 and 2.63 $\mu\text{g-at P/L}$ respectively. The mean total nitrogen, ammonium and nitrate levels in the estuarine waters ranged between 8.22 and 73.99 $\mu\text{g-at N/L}$, 1.04 and 22.44 $\mu\text{g-at N/L}$, and 0.01 and 8.64 $\mu\text{g-at N/L}$ respectively. The DON (51.60 – 64.99 % of N), DOP (88.44 – 89.81 % of P), and ammonium (20.29 – 24.67 % of N) are the dominant species detected in the estuary. The N:P ratio is approximately 5:1 with DIN:DIP ratio of 18:1. This reveals that the original source of nutrients in Terengganu River estuary is derived from sewage. The DOC was the most fluctuated nutrient species compared to nitrogen and phosphorus throughout the year with ranges between 0.35 mg C/L and 11.02 mg C/L. The active housing and industrial activities along the riverbank of the southern part have a great influence on the nutrient and sewage distributions in the estuary.

Low DO accompanied by the high BOD₅ level was detected in the estuary water. For fecal coliform bacteria, most of the sampling stations showed levels higher than the interim microbiological standard of log mean 100 MPN/100 mL throughout the year. The log-mean MPN/100 mL of fecal coliform bacteria in the riverine, estuarine, and coastal waters during the NE and SW monsoon seasons were 136 and 466, 138 and 728, and 458 and 920 MPN/100 mL respectively. However, fecal coliform count showed weak correlations ($R^2 = < 0.5$) with most of the parameters analyzed. A mean value ranging between 1.3 and 35.0 MPN/gram was obtained in the sediment.

In general, the amount of total phosphorus (mean value: 1.10×10^4 ton P/year) flushed out to the sea was higher than the nitrogen (mean value: 6.22×10^4 ton N/year). DOC flushed out to sea with a mean rate of 3.84×10^4 ton C/year. Nutrients flushed to South China Sea occurred throughout the year because of the high water flowing rate of this estuary.

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

TABURAN DAN FLUKS KARBON, NITROGEN DAN FOSFORUS DI MUARA SUNGAI TERENGGANU

Oleh

JONG KHIAM JAN

September 2002

Pengerusi : Prof. Dr. Law Ah Theem, Ph.D.

Fakulti : Sains dan Teknologi

Kajian terhadap taburan nutrien (karbon, nitrogen dan fosforus), BOD₅, jumlah kealkaliniti, bakteria fecal koliform dan ciri-ciri hidrologi di muara Sungai Terengganu, Laut China Selatan telah dijalankan. Kajian ini dijalankan secara bulanan dari September 1999 ke September 2000. Sejumlah 14 stesen penyampelan telah dipilih untuk kajian. Sampel air diambil pada paras permukaan, pertengahan dan dasar sungai dalam setiap stesen kajian. Sebanyak 11 kali penyampelan telah dijalankan.

Muara Sungai Terengganu merupakan satu muara sungai yang unik dan kemasukan air laut adalah bermusim. Hujan monsun akan mencairkan kandungan nutrien dan bahan kumbahan dalam muara sungai. Masa pertukaran dalam muara sungai ini adalah di antara 12.22 jam dan 15.63 jam. Pasang surut didapati

kurang memberikan kesan terhadap taburan nutrien dan kumbahan dalam kawasan kajian pada musim tengkujuh (monsun Timur Laut). Punca utama air muara ini adalah dari sungai dan air hujan.

Secara umumnya, kualiti air kawasan kajian masih memenuhi kriteria kualiti air untuk akuakultur. Taburan suhu dan pH didapati bertaburan secara normal seperti kebanyakan muara sungai yang lain. Semua parameter yang dikaji menunjukkan tahap yang tinggi pada musim kemarau (monsun Barat Daya) berbanding pada musim tengkujuh (monsun Timur Laut) kecuali nitrat yang menunjukkan taburan yang sebaliknya. Semua nutrien yang dikaji menunjukkan perbezaan yang ketara ($p < 0.05$) kecuali nitrit and fosforus mengikut kedalaman sungai dan musim.

Tahap nitrit (NO_2^-) dan ortho-fosfat (PO_4^{3-}) yang rendah dengan julat antara 0.01 dan 0.76 $\mu\text{g-at N/L}$ serta 0.04 dan 2.63 $\mu\text{g-at P/L}$ masing-masing telah dikesan dalam kajian ini. Nilai purata jumlah nitrogen, ammonium, nitrat yang diperolehi dalam muara sungai ini adalah masing-masing berjulat antara 8.22 dan 73.99 $\mu\text{g-at N/L}$, 1.04 dan 22.44 $\mu\text{g-at N/L}$, serta 0.01 dan 8.64 $\mu\text{g-at N/L}$. Keputusan menunjukkan bahawa nitrogen organik terlarut - DON (51.60 – 64.99 % daripada jumlah N), fosforus organik terlarut - DOP (88.44 – 89.81 % daripada jumlah P), dan ammonium (20.29 – 24.67 % daripada jumlah N) merupakan nutrien yang kelimpahan tinggi dalam muara sungai tersebut. Nisbah N:P yang dikira adalah 5:1 dengan nisbah DIN:DIP adalah 18:1. Nilai yang tinggi ini menunjukkan punca utama kemasukan nutrien ke dalam sistem muara Sungai Terengganu ini adalah daripada bahan kumbahan. Taburan karbon organik terlarut (DOC)

didapati tidak menentu berbanding dengan nitrogen dan fosforus komponen di sepanjang masa kajian. Julatnya adalah di antara 0.35 mg C/L dan 11.02 mg C/L. Pembangunan serta aktiviti industri yang pesat di sepanjang bahagian selatan tebing muara sungai didapati banyak mempengaruhi taburan nutrien dan bahan kumbahan dalam muara sungai ini.

Tahap oksigen terlarut (DO) yang rendah, yang disertai dengan nilai keperluan oksigen biokimia (BOD_5) yang tinggi telah dikesan dalam sungai muara ini. Untuk bakteria fecal koliform, kebanyakan stesen kajian menunjukkan tahap yang melebihi nilai "interim microbiological standard" yang telah ditetapkan dengan nilai log mean 100 MPN/100 mL pada sepanjang tahun. Nilai log-mean MPN/100 mL yang dikesan dalam sungai, muara serta air persisiran pada musim tengkujuh dan kemarau adalah masing-masing 136 dan 466, 138 dan 728, dan 458 dan 920 MPN/100 mL. Namun, tahap bilangan paling mungkin (MPN) yang dikesan menunjukkan kolerasi yang lemah ($R^2 = < 0.5$) dengan kebanyakan parameter yang dikaji. Tahap bakteria fecal koliform dalam sedimen dengan berjulat antara 1.3 and 35.0 MPN/gram telah dikesan dalam muara ini.

Umumnya, fluks jumlah fosforus yang mengalir keluar ke Laut China Selatan (nilai purata: 1.10×10^4 ton P/tahun) adalah lebih tinggi berbanding dengan nitrogen (nilai purata: 6.22×10^3 ton N/tahun). Nilai purata fluks karbon organik terlarut adalah 3.84×10^4 ton C/tahun. Nutrien telah dikesan mengalir keluar ke Laut China Selatan sepanjang tahun. Ini adalah disebabkan oleh kadar fluks yang tinggi di dalam sistem muara Sungai Terengganu ini.