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

**TEMPORAL AND SPATIAL VARIATIONS OF NUTRIENTS AND DISSOLVED GREENHOUSE GASES CONCENTRATIONS IN KENYIR LAKE, MALAYSIA**

**SITI FARHAIN BINTI MOHD LUDIN**

**OCTOBER 2021**

**Main Supervisor : Associate Professor Poh Seng Chee, Ph.D**
**Faculty : Faculty of Science and Marine Environment**

Freshwater lakes represent significant sources of greenhouse gas emissions, largely influenced by nutrient enrichment within the water column. This study evaluates the dynamic of dissolved carbon dioxide ($CO_2$) and methane ($CH_4$) distribution patterns in Kenyir Lake, aiming for a better understanding of the physical processes controlling internal loading of $CO_2$, $CH_4$, and nutrients in one of the largest freshwater lakes in Malaysia. The distribution of $CO_2$, $CH_4$, nutrients, and physicochemical parameters in the water column of Lake Kenyir was determined from November 2017 to November 2018. During this period, water samples were collected at different depths to measure $CO_2$ and $CH_4$ using headspace gas chromatography, nutrients using the colorimetric method, and basic water quality parameters using a portable water quality meter. The study showed the level of thermal stratification in the Kenyir Lake varied across seasons. The hypolimnion often remains around 3-6 °C cooler than surface water temperature (28-32 °C) throughout the year. During the raining seasons (November 2017, February 2018, and November 2018), both the Schmidt stability index and Lake Number (Ln) decreased significantly. This indicated enhanced mixing of epilimnetic water with deeper hypolimnetic water particularly from the surface down to 40 m. However, complete lake turnover did not occur during the study period. Despite the upper layer mixing, Kenyir Lake remained thermally stratified, leading to the accumulation of $CO_2$, $CH_4$, and inorganic nutrients in the bottom layers of the lake. Dissolved $CO_2$

and $CH_4$ concentrations in Kenyir Lake ranged from 1.30-925 µM and 0.10-4226 µM, respectively. Spearman's correlation analysis shows addition of nitrogen and phosphorus-based nutrients resulted in an increase in $CH_4$ production in the lake. A stronger linear relationship between $CH_4$ and $CO_2$ concentration was observed during the dry season ($r^2$=0.85) compared to the raining season ($r^2$=0.46), suggesting that the methane oxidation may play a prominent role in contributing to $CO_2$ levels in lake water during the dry season. The significant greenhouse gas emissions observed in Kenyir Lake underscore the need for similar assessments in other major freshwater lakes across Malaysia. These findings contribute to national climate reporting efforts and support evidence-based lake and watershed management policies.

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

**VARIASI MASA DAN RUANG KEPEKATAN NUTRIEN DAN GAS RUMAH HIJAU TERLARUT DI DALAM TASIK KENYIR, MALAYSIA**

**SITI FARHAIN BINTI MOHD LUDIN**

**OKTOBER 2021**

**Penyelia Utama : Profesor Madya Poh Seng Chee, Ph.D**
**Fakulti : Fakulti Sains dan Sekitaran Marin**

Tasik air tawar merupakan sumber utama pelepasan gas rumah hijau, sebahagian besarnya dipengaruhi oleh pengayaan nutrien dalam turus air. Kajian ini menilai corak taburan dinamik karbon dioksida ($CO_2$) dan metana ($CH_4$) terlarut di Tasik Kenyir dengan tujuan untuk memahami proses fizikal mengawal pemuatan dalaman $CO_2$, $CH_4$ dan nutrien dalam salah satu tasik air tawar terbesar di Malaysia. Taburan $CO_2$, $CH_4$, nutrien dan parameter fizikokimia dalam lajur air Tasik Kenyir telah ditentukan dari November 2017 hingga November 2018. Sepanjang tempoh ini, sampel air diambil pada pelbagai dalaman untuk mengukur $CO_2$ dan $CH_4$ dengan kaedah kromatografi gas secara ruang kepala, nutrien menggunakan kaedah kolorimetrik, dan parameter kualiti air asas menggunakan meter kualiti air mudah alih. Kajian ini menunjukkan stratifikasi terma di Tasik Kenyir berubah mengikut musim. Suhu di hipolimnion didapati kekal sekitar 3-6 °C, lebih sejuk berbanding suhu permukaan air (28-32 °C) sepanjang tahun. Sepanjang musim hujan (November 2017, Februari 2018 dan November 2018), kedua-dua indeks kestabilan *Schmidt* dan *Lake Number* (Ln) menurun dengan ketara. Ini menunjukkan peningkatan pencampuran air epilimnion dengan air hipolimnion yang lebih dalam, khususnya dari permukaan air tasik hingga kedalaman 40 m. Namun, pemutaran penuh air tasik tidak berlaku sepanjang tempoh kajian ini. Walaupun berlaku pencampuran di lapisan atas, Tasik Kenyir kekal mengalami stratifikasi terma, yang mengakibatkan pengumpulan $CO_2$, $CH_4$ dan nutrien tak organik di lapisan dasar tasik. Julat

kepekatan $CO_2$ dan $CH_4$ terlarut di Tasik Kenyir masing-masing adalah antara 1.30-925 µM dan 0.10-4226 µM. Analisis korelasi Spearman menunjukkan bahawa peningkatan nutrien berasaskan nitrogen dan fosforus boleh meningkatkan $CH_4$ di dalam tasik. Hubungan linear yang lebih kuat antara kepekatan $CH_4$ dan $CO_2$ telah diperhatikan semasa musim kering ($r^2$=0.85) berbanding musim hujan ($r^2$=0.46). Ini menunjukkan bahawa proses pengoksidaan metana mungkin memainkan peranan penting dalam menyumbang kepekatan $CO_2$ dalam air tasik semasa musim kering. Pelepasan gas rumah hijau yang ketara di Tasik Kenyir menyerlahkan keperluan untuk penilaian serupa di tasik air tawar utama lain di seluruh Malaysia. Penemuan ini menyumbang kepada usaha pelaporan iklim negara dan menyokong dasar pengurusan tasik dan kawasan tadahan berasaskan bukti.