Greater Kenyir Landscapes
Greater Kenyir Landscapes

Social Development and Environmental Sustainability: From Ridge to Reef
Preface and Acknowledgements

The Greater Kenyir landscapes are varied from Mount Gagau in the pristine Taman Negara (National Park) to the man-made Tasik Kenyir, Sungai Terengganu valley, coastal zone and the Terengganu offshore islands. The vast area is subjected to constant exploitation for economic development that calls for the need for research to document its physical features, ecosystems and the communities that are constantly adapting to the environment. Many researchers from the Universiti Malaysia Terengganu have taken the challenge to observe and record the natural and disturbed environments and aspects of the human livelihood and management. The physical scientists describe the climatic condition of the Tasik Kenyir, physical characteristics of the Setiu Wetland and polycyclic aromatic hydrocarbon in the National Park. The biologists describe the wide-ranging resources from bryophytes, fungi, ginger, woody plants, invertebrates and vertebrates. The final section of the book deals with modeler who explore the eco-tourism potentials of Tasik Kenyir and social scientists who examine the livelihood of the local communities along Sungai Terengganu and the domestic water issues and challenges.

This book will provide the basic knowledge on the Greater Kenyir as well as the gap for deep research by future scientists who are interested in the environmental issues that are facing the tropical rainforest region. As we progress for economic prosperity, humans have greater appetite for land, while the primary forest is shrinking and rivers are getting murky. We also aspire to be a First World Nation by 2020. As a benchmark of a developed nation, our children should be able to swim in a pristine Sungai Terengganu and hear the glorious sounds of birds and gibbons in the nearby forests.
The editors and authors are very grateful to numerous research grants and support provided by the Ministry of Education and the Universiti Malaysia Terengganu that are acknowledged in the chapters, and the untiring staff members of Springer Publication for the support and engagements with the book project editors.

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Photo Credit

Additionally, the astonishing photographs in this book were taken by our professional photographer, better known as Dome.
Greater Kenyir: Landscapes, Social Development and Environmental Sustainability

From Ridge to Reef

This book offers an uncommon glimpse of the vibrant tropical rainforest biome and the physical features in the state of Terengganu situated on the east coast of Peninsular Malaysia. Greater Kenyir is a vast landscape of natural topographies intermixed with man-made structures. Combining those landscapes from the natural heritage of Taman Negara (National Park), well-preserved ridge of Mount Gagau to the pristine riparian and lowland dipterocarp forest, man-made structure of Kenyir Lake (Tasik Kenyir), industrial agricultural oil palm crop, local fruit orchard, villages, townships, wetlands, coastal forest and to the off-coast islands that provided the dynamism of Terengganu’s ecosystems. All over these areas there are numerous cultural and biological diversity for the maintenance of livelihood of many Malay communities and indigenous people.

The tropical rainforest is functioning countless ecological and environmental services from the regulation of climate and temperatures, pollination for the healthy maintenance of the forest trees, as specialised niches for hyperdiversity of fauna and
flora, as carbon sink and also to provide clean water supply that feed many rivers and man-made lake of Kenyir. During the north-east monsoon seasons that usually produce high precipitation to sustain the Kenyir reservoir capacity to produce continuous cheaper hydroelectric power to feed for industry and domestic use in Terengganu as well as to other industrial areas on the western parts of Malaysia.

High rate of development is manifested with the fragmentation of habitats and wildlife populations in the Greater Kenyir. Our dedicated scientists spent thousands of hours observing and documenting those biological and physical interactions affecting the ecosystems in the landscapes. Anthropogenic activities produce particulate matters that infiltrate from the terrestrial areas into the aquatic environment.
The dynamic of social, economic and ecological interactions resulted in the resilience of the rural community to maintain sustainable livelihood. The river communities in the Greater Kenyir are relatively poor small-scale farmers earning about USD230 per month, while the farmer-trader group earn about USD460. For the rural communities, they are able to tackle the challenge of low income in the face of uncertainties of environmental and economic changes.

This book will provide basic information for new researchers and undergraduate students as reference point for the Greater Kenyir. It is hoped that it will stimulate future debate on the sustainability of our development that is decreasing the resources in the Kenyir landscape.
View of Tasik Kenyir in 1984 (Photograph by Ab Wahab)
Lower Sungai Terengganu below the Kenyir Dam
About the Editors

Mohd Tajuddin Abdullah is a Professor at the School of Marine and Environmental Sciences, Universiti Malaysia Terengganu. He received his PhD in Zoology from the University of Queensland, Australia; MSc and BSc from the West Virginia University, USA; and Diploma in Forestry from the Institut Teknologi MARA, Malaysia. He was elected and inducted as a Fellow in the Academy of Sciences Malaysia on 8 June 2013 and DIMP from the Royal Highness the Sultan of Pahang. His research discipline is in biology with specialisation in zoology, molecular ecology, biodiversity and protected area management. In the 1970s to 1990s, he studied on the endangered Sumatran rhinos. In the late 1990s, he studied in Borneo on the wildlife diversity, distribution, population, ecology and species conservation and their natural habitats. From 2000 to 2014, he used molecular methods to study on the ecology, biogeography and evolution of mammals in Borneo and Peninsular Malaysia. From 2011 he received grants to study on zoonoses, genome and metagenomic of primates. From 2014 onwards he worked in the Greater Kenyir, on the canopy wildlife distribution patterns in the dipterocarp forest, wetlands and islands on the east coast of Malaysia.

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Part I
Physical Environment
Abstract This study investigates the trend of weather and climate in Tasik Kenyir, Terengganu State based on seasonal monsoons utilizing nearest meteorological station of Kuala Terengganu. Data from 1985 to April 2016 was used to describe the physical environment of Kenyir Lake in terms of rainfall amount (mm), relative humidity (%), ambient temperature (°C), MSL pressure (hPa), and wind speed (m/s) and wind direction (degrees). The data was first divided by different monsoon seasons faced by Kuala Terengganu; Southwest Monsoon (SWM), Northeast Monsoon (NEM) and Inter Monsoon (IM). There exists significant different (p < 0.05) during these three monsoon seasons for rainfall amount, ambient temperature, and MSL pressure. Conversely, relative humidity shows no significant different between the monsoon seasons. Rainfall amount, relative humidity and MSL pressure noted high intensity during NEM with an increment of 250.1 mm, 0.3%, and 2.2 hPa from SWM and by 189.2 mm, 0.2%, and 1.3 hPa from IM, respectively. Meanwhile, there was a decrease of ambient temperature during NEM by 1.1 °C from SEM and 0.8 °C from IM. Prevailing wind direction was noticed from NE direction with mean value of 3.5 m/s. In conclusion, regardless of any monsoon seasons, there is no significant change in relative humidity variation, but rainfall amount, ambient temperature and MSL pressure shows significant change for each and every monsoon. The understanding of indigenous community on the changing of monsoon seasons might help them in early preparation for foods and other materials for their own survival and festive activities.

Keywords Meteorological parameter · Monsoon seasons · Tasik Kenyir · Terengganu
Introduction

Malaysia is characterized as having climate of hot and humid throughout of the year, since it is situated near the equator (Ismail et al. 2015a, b). The weather and climate is generally defined through several meteorological parameters. The most important meteorological parameter is rainfall intensity or rainfall amount. The rainfall plays an important role in the distribution of heavy or light rain over the areas. Not to be neglected, some of the other meteorological parameters are also important in defining the weather of an area. Those are ambient temperature, relative humidity and MSL pressure. Wind speed and wind direction are the two key meteorological parameters in determining the prevailing wind of an area.

Tasik Kenyir is situated in Terengganu State of Peninsular Malaysia. Terengganu State is located in East Coast of Peninsular Malaysia which was popularized with the known beaches and islands. The east coast of Peninsular Malaysia experienced several monsoons seasons, southwest monsoon (SWM), northeast monsoon (NEM) and inter monsoon (IM) (Abdullah et al. 2017). The main characteristic of SWM is dry seasons and NEM is wet seasons. In defining the weather and climate of Tasik Kenyir, the analysis was based on these three monsoon seasons. This study highlights the trend of selected meteorological parameters and determines the significant change of each parameter throughout different monsoon seasons. The changes of monsoon seasons is believe in affecting indigenous populations in terms of restriction in accessing a safe and nutritious food, which including traditional foods that is considered very important for cultural practices. The changes of seasons also trigger to the threatening of cultural identities of indigenous people as such plants and animals used in traditional practices or scared ceremonies become less available. By understanding of the trend of monsoon seasons, early steps can be taken by this community for early preparation for their foods and festive activities.

In conjunction describing the weather and climate of Tasik Kenyir, the nearest meteorological station was used in acquisition of data. Kuala Terengganu Meteorological Station was selected in representing the weather and climate of Tasik Kenyir. It is precisely located at coordinate: 5°23’07.4″N; 103°06’37.0″E as shown in Fig. 1. The distance between the Kenyir Lake (5°00’N; 102°48’E) and Kuala Terengganu Meteorological Station was 66.94 km.

The parameters taken into consideration were rainfall amount (mm), mean sea level pressure (MSLP) (hPa), relative humidity (%), temperature (°C), wind speed (m/s), and wind direction (degrees), all are monthly basis data. The data covers period from year 1985 to 2016 (32 years). The completeness of data in an analysis is important in terms of maintaining the data reliability (Suhaila et al. 2010). In this study, no imputation of missing data was performed as the data was complete for that period. Climate of Terengganu is best described by different monsoon seasons. The data management was performed in dividing the data into three main monsoon seasons. The southwest monsoon (SWM) occurs from May to August, northeast monsoon occurs from November to February and inter-monsoon occurs during September to October and March to April (Daryabor et al. 2014; Suhaila et al.
Therefore three main data sets were extracted which having different monsoon seasons (except for wind speed and wind direction) and statistical analysis was performed on these data sets.

The trend of weather and climate of Tasik Kenyir was determined by constructing the boxplot. Boxplot is describe statistically and act as visual aid which the data was represented by distribution of rectangle containing several information in the data set such as minimum, maximum, first quartile, third quartile, median and mean values (Ismail et al. 2016). The statistically significant different among the monsoon seasons for each parameters considered was tested by applying Analysis of Variance (ANOVA) whereby the evaluated of P-value of less than (<0.05) concludes that there exist significant different among monsoon seasons and vice versa (Ismail et al. 2015a, b). The analysis was taken at 95% confidence interval. Microsoft Excel Spreadsheet 2013 was used for tabulation and analysis of data.

**Patterns of Meteorological Parameters During Different Monsoon Seasons**

The trend of rainfall amount, temperature, relative humidity and MSL pressure during different monsoon seasons was described in Fig. 2. The trend of rainfall amount on average was same with MSL pressure which the highest was denoted during NEM with rainfall amount of 370.0 mm, and MSL pressure of 1011.4 hPa. Temperature shows that on average, NEM has lowest temperature with 26.5 °C. It indicates that as the increasing rainfall amount, will result in decreasing of
temperature. The trend of relative humidity is slightly constant during the three monsoon seasons with range of 82.8–83.0%. Descriptively, the highest mean for rainfall amount was 370.0 mm, where it increased by 191.4 mm from IM and 252.2 mm from SWM. Generally, rainfall amount at east coast of Peninsular Malaysia during NEM is higher as it receives heavy rainfall. Eastern part of Peninsular Malaysia is not blocked by Titiwangsa Range, and therefore heavy rain was bring by northeasterly winds towards east coast, consequently has wettest area during NEM (Akhir and Chuen 2011; Suhaila et al. 2010). NEM recorded lowest mean value of temperature with 26.5 °C, where it decreased by 0.8 °C during IM and 1.1 °C during SWM. It is noted SWM is the drier period for the whole Malaysian Peninsular. There is no slight change of mean values in relative humidity during the monsoon seasons with 82.7%, 83.0%, and 82.8% for SWM, NEM, and IM, respectively. The highest mean for MSL pressure was 1011.4 hPa, where it increased by 1.2 hPa from IM and 2.2 hPa from SWM. The analysis of wind speed and wind direction was based on the data January 1970 to April 2016. Prevailing wind direction was noticed from NE direction with mean value of 3.5 m/s (Fig. 3). The other summary of wind direction and mean values of winds speed were; N (3.3 m/s), E (2.8 m/s), SE (2.3 m/s), S (1.5 m/s), SW (1.5 m/s), W (1.5 m/s), and NW (2.4 m/s).

The differences of each selected weather parameters is further confirmed with the ANOVA. ANOVA was performed in determining the significant different of each parameter during different monsoon seasons. Results show that rainfall amount, temperature and MSL pressure has statistically significant different (P < 0.05) with the P-value of $1.37 \times 10^{-16}$, $5.04 \times 10^{-39}$ and $8.06 \times 10^{-51}$, respectively.
during the three monsoon seasons, conversely relative humidity has no significant different (P > 0.05) with 0.5918 during the different monsoon seasons.

**Conclusion**

The data of monthly basis from year 1985 to April 2016 was acquired form MMD of Kuala Terengganu Meteorological Station representing Tasik Kenyir, Terengganu. Parameters used were rainfall amount, relative humidity, ambient temperature, MSL pressure, and wind speed and wind direction. The analysis was conducted based on the different monsoon seasons in Peninsular Malaysia namely; SWM, NEM and IM. Results revealed that the trend of rainfall amount and MSL pressure is slightly same with highest mean values during NEM, conversely, ambient temperature has lowest mean values during NEM. Prevailing wind direction was noticed from NE direction with mean value of 3.5 m/s. ANOVA shows that there exist statistically significant different of rainfall amount, ambient temperature and MSL pressure during different monsoon season, while there is no significant different for relative humidity over the monsoon seasons. The comprehension of indigenous group on the different seasons may help them in early readiness for sustenance and different materials for their own particular survival.
Acknowledgements  This study was funded by Universiti Malaysia Terengganu Scholarship Scheme (BUMT) to Author 1. The authors also would like to thank the Malaysian Meteorological Department (MMD) for the meteorological data.

References


A Preliminary Assessment of Water Quality Status in Tasik Kenyir, Malaysia

Suhaimi Suratman, Edmand Bedurus, Suzana Misbah, and Norhayati Mohd Tahir

Abstract  The preliminary study of water quality which involved the measurement of physical, chemical and microbiological parameters was conducted in Tasik Kenyir, Malaysia from August until October 2010. Results showed that the water quality of the surface water was in ‘clean’ status based on Malaysian Water Quality Index. However, the bottom water was in ‘slightly polluted’. According to National Water Quality Standard, all stations was in Class I which is suitable for conservation of natural environment, water supply with practically no treatment and fishery activity for very sensitive aquatic species.

Keywords  Water quality index · National water quality standard · Sustainable water · Tasik Kenyir

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Introduction

Numerous studies have been conducted in the early years since the establishment of Tasik Kenyir to determine water quality in relation to the effects of sustainable aquaculture, fish diversity and fish stock assessment, zooplankton dynamics and production (Jamaludin and Machiels 1999; Yusoff and Ambak 1999; Verhallen and Verhagen 1994). The increase of visitor numbers to Tasik Kenyir and the rapid development in the area might increase the possibility of deforestation and sewage discharge into the lake. These factors might then decrease the water quality of the lake. Therefore, the present study was carried out to establish the current status of the water quality by measuring the physical, chemical and microbiological (Escherichia coli and total coliform) parameters. The Water Quality Index (WQI) was also calculated according to Department of Environment-WQI (DOE-WQI) as tabulated in Table 1 (Department of Environment 2011). In addition, data obtained was compared to National Water Quality Standard (NWQS) classification to understand the beneficial uses of the water body (Table 2) (Department of Environment 2011).

<table>
<thead>
<tr>
<th>Table 1 DOE-WQI calculation formula (Department of Environment 2011)</th>
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<tbody>
<tr>
<td>Subindex DO (SIDO) (% saturation)</td>
</tr>
<tr>
<td>8&lt; x &lt;92</td>
</tr>
<tr>
<td>x \geq 92</td>
</tr>
<tr>
<td>Subindex BOD (SIBOD) (mg/L)</td>
</tr>
<tr>
<td>x &gt;5</td>
</tr>
<tr>
<td>Subindex COD (SICOD) (mg/L)</td>
</tr>
<tr>
<td>x &gt;20</td>
</tr>
<tr>
<td>Subindex AN (SIAN) (mg/L)</td>
</tr>
<tr>
<td>0.3&lt; x &lt;4</td>
</tr>
<tr>
<td>x \geq 4</td>
</tr>
<tr>
<td>Subindex TSS (SITSS) (mg/L)</td>
</tr>
<tr>
<td>100&lt; x &lt;1000</td>
</tr>
<tr>
<td>x \geq 1000</td>
</tr>
<tr>
<td>Subindex pH (SIpH)</td>
</tr>
<tr>
<td>5.5\leq x &lt;7</td>
</tr>
<tr>
<td>7\leq x &lt;8.75</td>
</tr>
<tr>
<td>x \geq 8.75</td>
</tr>
</tbody>
</table>

DOE-WQI = (0.22*SIDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16*SITSS) + (0.12*SIpH)
DOE-WQI = 0–59 (Polluted); 60–80 (Slightly Polluted); 81–100 (Clean)
Three sampling surveys were conducted from August until October 2010. Generally, there were two major areas involved, the eastern part of Tasik Kenyir (ELK, stations K1–K15) and Terengganu National Park (TNP, stations N1–N17) which is located in western part of Tasik Kenyir (Fig. 1). In ELK, the water samples were collected from both surface (~1 m depth) and bottom waters (i.e. 30 m depth), along two main transects, which were Transect one (station K1–K10) and Transect two (station K11–K15) using a Van Dorn sampler. In TNP, scattered sampling stations were distributed throughout the region and only surface waters (~1 m) were collected due to shallowness of the water column. In addition, samples for microbiological parameters were only carried out at TNP. Water samples were filtered through 0.45 μm pore size cellulose acetate membrane filters and decanted into 1 L
polyethylene bottles for storage prior to dissolved ammonia determination. Surface water samples for microbiological analysis were subsampled directly into 500 mL sterilized Scott bottles. All water samples were stored in an ice chest and transported to the laboratory where all samples were analysed on the same day.

Temperature, pH and dissolved oxygen (DO) were measured in-situ using YSI 6600 multiparameter data logger. Calibration of the instrument was made 24 h before the sampling as per the manufacturer’s recommendation. Ammonia was determined

Fig. 1 Sampling stations in Tasik Kenyir
colorimetrically according to Grasshoff et al. (1983) with total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were based on standard methods (American Public Health Association, 2005). The membrane filtration technique used for the detection and quantification of *E. coli* and total coliform according to the standard methods (American Public Health Association 2005). The number of coliforms were reported on a colony-forming unit per 100 mL basis (CFU/100 mL). Six parameters i.e. pH, DO, BOD, COD, TSS and ammonia were used to calculate the DOE-WQI (Department of Environment 2011). Significant difference for each parameter between different stations and depths were determined by using Analysis of Variance (ANOVA) test.

**Temperature**

The temperature for surface water of ELK was in the range of 29.9–30.8 °C (mean: 30.4 ± 0.3 °C) (Fig. 2a, b). The range of temperature for surface water in TNP was wider, with values between 23.7 and 31.7 °C (mean: 29.6 ± 2.5 °C). The temperature of bottom water in ELK stations are not reported due to loss of data. Low values recorded at few stations upstream of TNP were expected to be due to sampling being carried out under the trees which shaded the water column.

ANOVA test showed there no significance difference between sampling stations (p > 0.05). Temperature values were in Class IIA and above based on NWQS classification. In general, the temperature range was normal for tropical Malaysia rainforest climate especially in lake system (Jawan and Sumin 2012; Wan Mohd Afiq and Md Pauzi 2012; Othman et al. 2009).

**pH**

In ELK, the pH value varied from 7.0 to 7.7 (mean: 7.3 ± 0.2) for surface water (Fig. 2). Meanwhile, the pH value for the bottom water was between 3.9 and 7.2 (mean: 5.4 ± 1.1). For TNP area, the pH value was ranging from 6.6 to 8.0 (mean: 7.5 ± 0.4). The two-way ANOVA test showed no significant difference between the stations (p > 0.05) for both ELK and TNP. However, there was significant difference between the surface and bottom water (p < 0.05) for ELK. Based on NWQS classification, most of the surface water was in Class I for both ELK and TNP. In contrast, most of bottom water fell into Class IV.

The pH values for surface and bottom waters were similar at station K1 and K8, due to the shallow of the water (<10 m). Generally, the pH value was in neutral range (6.6–8.0) for surface water while the bottom water (for depth ≥30 m) was acidic (pH ≤6.5). This was probably due to the decomposition process of organic matter (dead trees) at the bottom part of the lake that caused the lower pH of the bottom water. The decomposition produced dissolved CO₂ gases in which turn into the weak acid known as carbonic acid (H₂CO₃) (Moran and Stottrup 2011).
Fig. 2  (a) Physical and chemical characteristics of Tasik Kenyir during present study. (b) Physical and chemical characteristics of Tasik Kenyir during present study