International Journal of Engineering & Technology, 7 (3.14) (2018) 67-74

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

The Potential Impacts of Anthropogenic and Climate Changes Factors on Surface Water Ecosystem Deterioration at Kenyir Lake, Malaysia

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Abstract

Water ecosystem deterioration can be affected by various factors of either natural environment or physical changes in the river basin.. Data observation were made during dry season (April 2017) and wet season (December 2017). 21 sampling stations were selected along Kenyir Lake Basin. Overall, the water quality status as stated in NWQS is categorized as Class I on dry season and Class II on wet season. The major pollutants in Kenyir Lake are Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Dissolve Oxygen and pH which are contributed largely by untreated or partially treated sewage from tourism development and construction activities around the basin. The sedimentation problem level in the Kenyir Lake Basin is not in critically stage but the flow rate of water and land use activities (development around basin) will be contributed to the increasing levels of sedimentation. The good site management such as the implementation of proper site practice measures to control and treat run-off prior to discharge will ensure that the construction works will not affect the quality and quantity of the receiving waters or have significant impact upon the receiving waters.

Keywords: *Kenyir Lake Basin; Water Ecosystem Deterioration; Wet season; Dry season; National Water Quality Standard (NWQS).*

1. Introduction

The water ecosystem deterioration status of lakes in Malaysia has always been a cause for concern for various local authorities, government agencies, NGO agencies as well as the public at large. Lakes in Malaysia are generally considered to be polluted with coherent examples Bera Lake, Chini Lake, Kulim Lake and Temenggor Lake [1-3]. The rapid urbanization and growth of the population were triggered the increasing demand of water consumption levels of water pollution at lakes in Malaysia. The rapid development around lake areas has produced great amounts of human wastes, including domestic, industrial, commercial, transportation, residential and tourism wastes into water bodies [4-6]. The wide variations in climatic changes and land use impacts whereas others are much more sensitive to any environmental change. In addition, the accidental or deliberate introduction of invasive non-native species can also severely impact communities of indigenous species in Kenyir Lake.

The role of lakes within the global hydrologic cycle or hydrological system depends for their very existence upon a balance between their many sources of water and the losses that they experience. This called water budget of lakes is important enough to have warranted considerable study throughout the world, with each lake or lake system possessing its own hydrologic system. These may include restrictions on water utilization especially during wet season and dry season to enhance water quantity and water quality management activities. To predicted imbalances in the hydrologic budget, it is usually difficult to influence the basic natural factors that cause the imbalances [7-11]. The water bodies quality monitored which is the Water Quality Index (WQI), which in turn is rooted on the National Water Quality Standards (NWQS), a set of standards derived based on beneficial uses for Malaysian freshwater. WQI is the best and accurate water quality benchmarking tools which used by the responsible agencies and parties involved in watershed management. The authorities must be aware of the implications and limitations of WQI to the preservation efforts process [12-16].

The land use change analysis suggested that the upstream area experienced most land use changes. In land use status planning for 2020, 7.04% (18594.29 hectares) of Hulu Terengganu areas will build a new dam, Kenyir Lake will be expanded as Hulu Terengganu Hydro Electric which including Sungai Tembat and Sungai Puah. This Project comprises of the development of two dams crossing Sungai Terengganu (which is the Puah Dam) and Sungai Tembat (which is the Tembat Dam). Both the water from the dams

flow to Kenyir Lake. Figure 1 and Table 1 showed the land changes of urbanization in Kenyir Lake Basin from 1976 until 2017. Majority of land use changes in basin covered of water body as Puah and Tembat Dam and only a small area of Kenyir Lake is allowed to be developed for the purpose of development. The highest increment of land changes density in the year 2010 – 2017 (70%).

Kenyir Lake is placed in the [17] *Rancangan Kawasan Khas* (RKK) and is prepared according to the requirements of subsections 16B (1), 16B (2) and 16B (3) of the Town and Country Planning Act 1976 (Act 172). The area of study is located in the environmentally sensitive areas of Level 1 and Level 2 because of its proximity to the Forest Reserve and high land area. Land use in Kenyir Lake can be divided into 9 types; Agriculture, Forestry, Water Body, Transportation and Road Reserves, Public Utilities, Residential, Leisure and Recreation Area, Infrastructure and Utility and Industry. The Agricultural Area is the largest land area in Kenyir Lake with a total area of 476.55 hectares which covering 52.83% of the total area. The forest area is the second largest land use in Kenyir Lake with an area of 308.80 hectares covering 34.23% from the total area. From 902 hectares, only a small area of Kenyir Lake is allowed to be developed for the purpose of development.

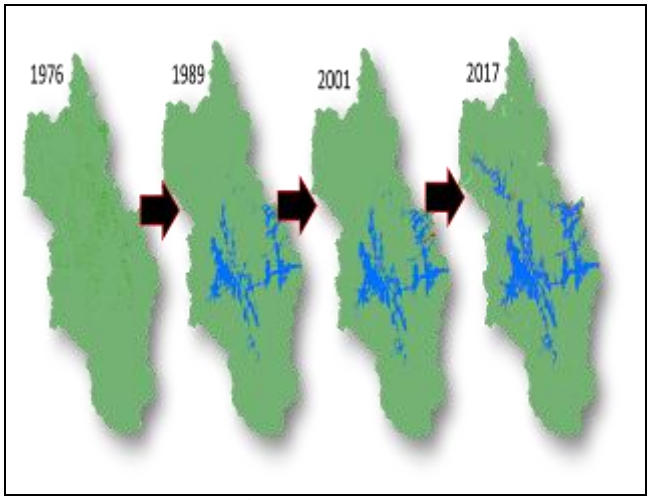

Fig. 1: The Land Changes of Urbanization in Kenyir Lake Basin, Hulu Terengganu, Terengganu from 1976 until 2017

Table 1: The Urbanization Level in Kenyir Lake Basin, Hulu Terengganu, Terengganu from 1976 until 2017

Year	Area (Urbanization) (Acres)
1976	0
1989	61.36
2001	1176.77
2017	2866.85

Table 2: Land Use Distribution of Kenyir Lake Basin, Hulu Terengganu, Terengganu

Landuse	Area (Hectares)	Percentage (%)
Forest	476.55	52.83
Water Body	308.80	34.23
Transportation And Road Reserves	46.81	5.19
Public Utilities	45.14	5.00
Residential	2.95	0.46
Leisure and Recreation Area	1.84	0.33
Infrastructure and Utility	15.66	0.20
Industrial	0.17	1.74
Total	902.00	100.00

The rainfall distribution is very important in study of physical environment of natural water areas such as lake, river and stream. There are three main sources of flooding such as heavy local rainfall, extreme river discharge and sea wave from South China Sea. Rainfall form main water input to the river basin. It is influence the water storage and discharge of a river especially during heavy rainfall event. The secondary data evaluate is from 1990 until 2014 which to represent the local climate at Terengganu (Figure 2) and specified at Kenyir Lake from 1985 - 2017 (Figure 3). From the secondary findings proved that the total annual rainfall distribution trends ranged 2000 mm (January) to 10000 mm (December) every year from 1985.

Temperature is important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen that cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life. Figure 4 showed the distribution of mean monthly temperature recorded at Felda Belara, Hulu Terengganu from 2001 until 2017. The highest mean temperature recorded on April, May and June every year and the lowest value during the wet season (November until January).

Relative humidity measures the current absolute humidity relative to the maximum (highest point) for that temperature. While humidity itself is a climate variable, it also interacts strongly with other climate variables. The humidity is affected by winds and rainfall and the energy budget and thereby influences temperatures. Figure 5 for Hulu Terengganu climatological station from 2001 to 2017. In general, relative humidity is slightly high. Relative humidity near 90% can be occurred in the mornings and during the monsoon season, because of an increase in moisture supply rather than a reduction in temperature. Similarly, saturation deficits during the monsoon are significantly smaller than during the pre-monsoon period (August-October), being almost as small as they are during the months of March and April, when air temperature and the amount of water that can be held by air are at their lowest [18].

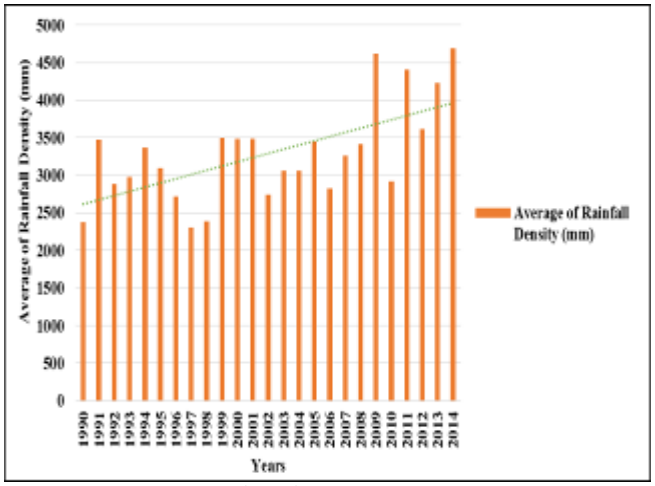

Fig. 2: The distribution of rainfall intensity at Terengganu (1990 until 2014)

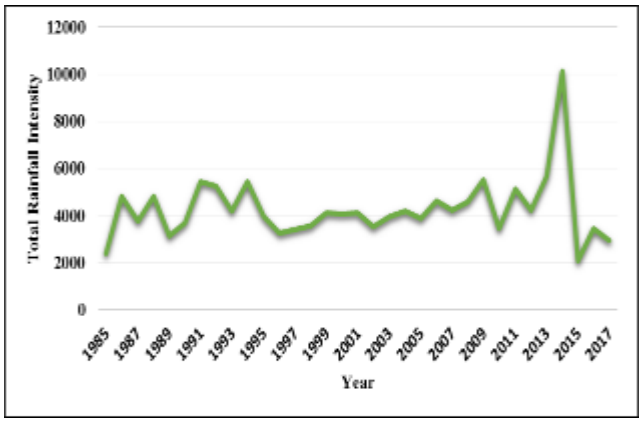

Fig. 3: The distribution of rainfall intensity at Kenyir Lake (1985-2017), Tenaga Nasional Berhad (TNB) Station

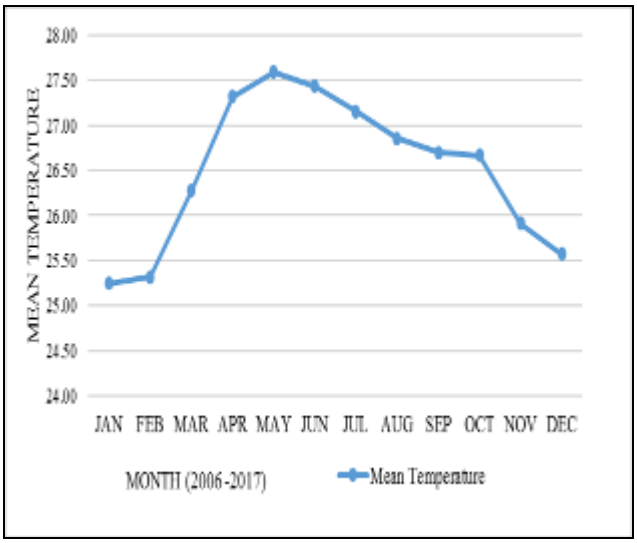

Fig. 4: The Mean Monthly Temperature Recorded at Felda Belara, Hulu Terengganu Meteorological Station (2006-2017)

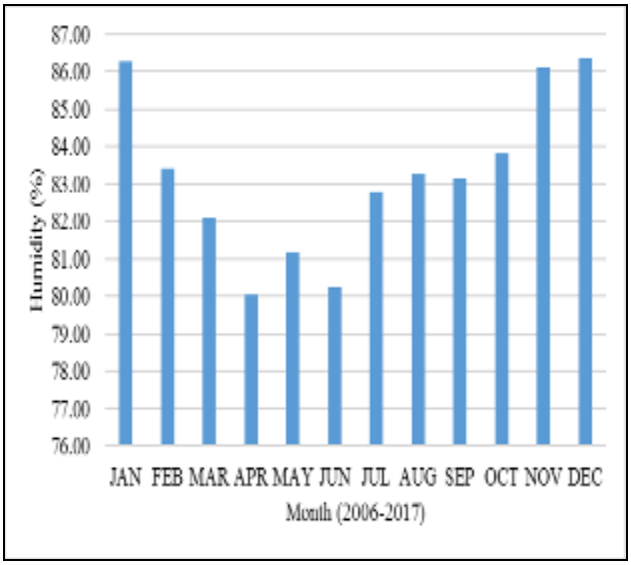

Fig. 5: The Mean Monthly Humidity Recorded at Felda Belara, Hulu Terengganu Meteorological Station (2006-2017)

2. Study Area

Lakes in Malaysia, natural or artificial, have multiple functions. Almost 90 percent of the nation's water supply comes from the lakes and reservoirs. Lakes and reservoirs serves as the source of water for domestic, industrial and agriculture, hydroelectric power generation, flood mitigation, navigation and recreation. They are also home to a variety of biological species and freshwater fish industry like Kenyir Lake. Kenyir Lake luxurious forest is located in the district of Hulu Terengganu and the world oldest tropical rain-forest. The lake is known as a unique tourist destination for her beautiful scenario of tropical forest and widely known for its valuable flora and fauna species. It is believed that the area is the habitat of more than 8000 species of flowers, 2500 species of plants and trees, 8000 species of orchids, 370 species of birds and 300 species of fresh water fish. This study involves 21 main sampling stations that has been determined using DGPS which located around the Kenyir Lake Basin representing the length of the Kenyir Lake (Table 3 and Figure 6). The fieldwork was performed on wet season and dry season: the first sampling (Sampling 1) was carried out in April 2017 (Dry season) and the second sampling (Sampling 2) was carried out in December 2016 (Wet season).

Table 3: The Sampling Stations for Dry Season (July 2017) and Wet Season (December 2017) at Kenyir Lake Basin, Hulu Terengganu, Terengganu, Malaysia, 2017

Stations	Location	River Name
Station 1	102° 42'42.602"E 05°11'01.064"N	Sungai Siput
Station 2	102°39'49.705"E 5° 17'42.360"N	Sungai Petuang
Station 3	102°38'19.879"E 5° 12'57.393"N	Sungai Tembat
Station 4	102°37'46.486"E 5° 11'24.258"N	Sungai Terengganu
Station 5	102°33'17.735"E 5° 03'30.462"N	Sungai Ketiar
Station 6	102° 34'15.044"E 04°58'03.613"N	Sungai Besar
Station 7	102° 33'09.379"E 04°56'16.506"N	Sungai Lepar
Station 8	102°35'13.374"E 4° 54'38.067"N	Sungai Lawit
Station 9	102° 42'04.9"E 04°52'32.0"N	Sungai Cenana
Station 10	102°41'24.427"E 4° 50'36.340"N	Sungai Bewah
Station 11	102°44'30.707"E 4° 47'42.302"N	Sungai Cicir
Station 12	102°44'31.9"E 4° 47'16.9"N	Sungai Perepek
Station 13	102°45'00.244"E 4° 46'28.235"N	Sungai Terenggan
Station 14	102°42'32.595"E 4° 48'17.089"N	Sungai Cacing
Station 15	102°48'00.5"E 4° 55'26.2"N	Sungai Pertang
Station 16	102°50'22.510"E 4°57'54.633"N	Sungai Lasir
Station 17	102°45'03.621"E 5° 02'21.528"N	Sungai Leban Terengganu
Station 18	102° 46'42.443"E 05°04'58.079"N	Sungai Sauk
Station 19	102° 20'6.25"E 05°07'34.463"N	Sungai Mandak
Station 20	102°54'5.18"E 05° 0'40.01"N	Sungai Kenyir
Station 21	102°54'40.34"E 05° 1'2.36"N	Sungai Berangan

Fig. 6: Map of Sampling Stations Location at Kenyir Lake Basin, Hulu Terengganu, Terengganu, Malaysia

3. Methodology

3.1. Water Quality Parameters Analysis

All the sample preparation and preservations conducted were following on the standard procedures provided by American Public Health Association (APHA) and United States Environmental Protection Agency (USEPA) Methods to analyse the in-situ and ex-situ parameters of Water Quality Index (WQI) status. The in-situ parameters were measured by using scientific equipment such as portable multipara meter probe (YSI Professional Plus, USA) to measure DO, pH and NH3-N and BOD concentration was measured by using portable BOD meter (Modern Water BOD check, UK). Chemical oxygen demand (COD) is defined as the amount of a specified oxidant that reacts with the sample under controlled conditions. The quantity of oxidant consumed is expressed in terms of its oxygen equivalence. The samples were placed into the icebox with temperature approximately 4°C during transportation to lower or retard the metabolism of the organism on the sample. All the samples were stored in the refrigerator at the temperature less than 6°C with covered layer to maintain dark condition. The overall laboratory analysis was completed within 14 days from the date of sample collection. The COD Low Range Reagent Vials, EPA Method used to analyse the COD. For Ultra Low Range Chemical Oxygen Demand (COD) determination by the Reactor Digestion Method (HACH Method 8000) with the range level between 0.7 until 40.0 mg/L of COD [19-21]. The Gravimetric method was used to analysis the Total Suspended Solid (TSS). 250 ml water sample was needed for each sampling station. TSS is measured by mg/L unit based on (Equation (1)) [22-26]. The precaution steps should be taken during water sample were taken. Interference of the river water flow should be minimum to avoid deposition of the measured suspended sediment [22, 23].

Total Suspended Solid (TSS) = {(WBF+ DR) - WBF} (mg) x 1000 / VFW (mL)
= mg/L/1000/1000/1000
= tonnes/L (1)

*WBF = Weight of membrane filter; DR = Dry residue; VFW = Volume of filtered water

3.2. Sediment Load Production (*Muatan Sedimen*) (MS) Analysis

The calculation of annual sediment load production (MS) based on the discharge value (Q) (m^3/s), TSS value (mg/L) and area of sampling basin (km^2). Equation (2) showed the following formula used in the measurement of MS (tonnes/km^2/year). Figure 7 showed the Fundamental of Georeferencing of ArcGIS method to determine the area of each sub catchments (area sampling basin) for 21 sub basin in Kenyir Lake Basin. Table 4 showed the area of 21 sub basin in Kenyir Lake Basin which are covered in this study to determine the MS production in 2017 along the dry and wet season. The discharge value (Q) is the product of velocity and cross section area (A). The cross section area is derived from the product of depth (d) and width (w), the cross section area is trapezium or tri-angular shaped and the value is half the product (Equation (3)-(5)), which are due to imprecision of the current meter, variability of the river flow velocity over the cross section and uncertainty in the estimation of the cross section geometry [22, 28-30].

Sediment load production (MS) = (Q x TSS)/ Area of sampling basin
= (L/day x tonnes/day) /km^2
= tonnes/km^2/365 days
= tonnes/km^2/days (2)

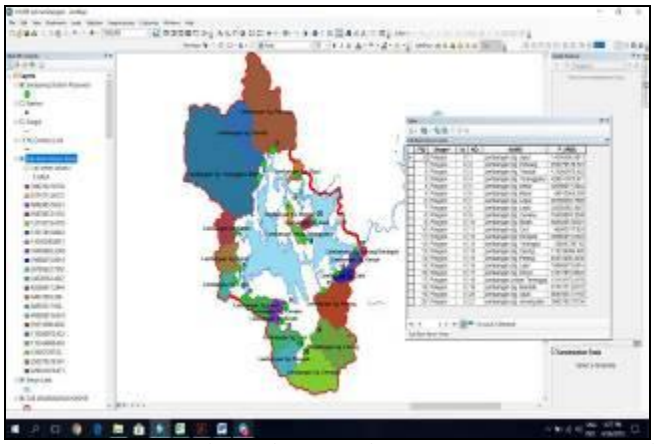

Fig. 7: Fundamental of Georeferencing of ArcGIS to determine the area of each sub basin of Kenyir Lake Basin, Hulu Terengganu, Terengganu

Table 4: The Area of Sub Basins in Kenyir Lake Basin, Hulu Terengganu, Terengganu

Sub Basin	Area Of Sub Basin (Km^2)
Sungai Siput	14.306
Sungai Petuang	250.280
Sungai Tembat	113.261
Sungai Terengganu	429.811
Sungai Ketiar	42.070
Sungai Besar	44.614
Sungai Lepar	26.786
Sungai Lawit	34.529
Sungai Cenana	18.406
Sungai Bewah	8.688
Sungai Cicir	48.593
Sungai Perepek	49.586
Sungai Terenggan	126.057
Sungai Cacing	113.334
Sungai Pertang	93.332
Sungai Lasir	19.961
Sungai Leban Terengganu	13.119
Sungai.Sauk	9.588
Sungai Mandak	8.174
Sungai Kenyir	13.318
Sungai Berangan	3.983

Cross section area (A)
A = dw (m) or A = ½ dw (m)
$\sum$ A1 + A2 + A3 + A4 (3)

Discharge value (Q)
Q = vA, or Q = ½ vA (4)

Q = m^3 /sec

To obtain the unit L/day, the following formula is used.

Q = m^3 /sec x 86400 sec/day x 1000 L/m^3 (5)
= L/day

4. Result and Discussion

4.1. Water Quality Parameters Level

The beneficial use of the water was also compared with the classification based on the NWQS. Water Quality Classification Based on DOE-WQI and NWQS for Malaysia. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. The range value of WQI was at Terengganu River Basin from 2009 until 2013 which 82% ± 88% (upstream), 79% ± 85% (middle stream) and 84% ± 90% (downstream). According NWQS classification the Terengganu River Basin from 2009 until 2013 in categorized under Class II which is considered slightly contaminated (Figure

8). Based on the DOE-WQI calculation (Figure 9), the water of the Kenyir Lake Basin (upstream until downstream) was classified as Class I (practically no treatment necessary), all stations showed WQI level more than 90% during dry season which is suitable for recreational activities where body contact still safe but a few stations (Sungai Cenana, Sungai Lasir, Sungai Tembat, Sungai Terenggan, Sungai Lawit, Sungai Lepar, Sungai Besar, Sungai Leban Terengganu, Sungai Petuang, Sungai Kenyir and Sungai Berangan) classified as class II (conventional treatment required) during wet season. However, there are an extensive treatment required. The management and control approach must be conducted to improve these problems before these issues become more serious as one of the conservation method. Low water quality was found at the around higher development activities, in contrast, high water quality was recorded at the stations of the basin which nearest natural park. The main sources of pollutants were possibly waste product and effluent which from development and activities in the construction, tourism, agricultural areas and inorganic wastes which ultimately contaminated the river basin [31]. Based on the NWQS, most of the parameters measured remained in Class I from the upstream to the down-stream stations. Various anthropogenic activities have caused significant changes in the water quality of the basin. The results presented here provide a baseline reference on the future monitoring of the Kenyir Lake Basin [1, 16, 32].

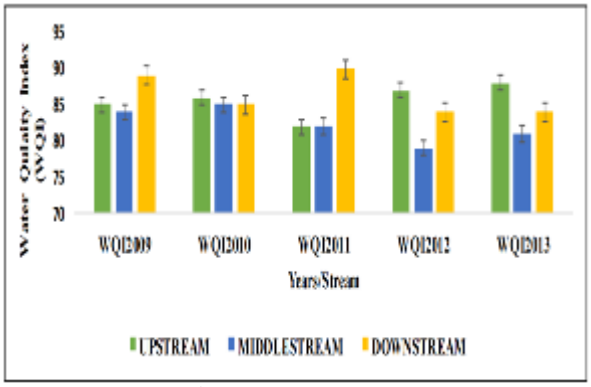

Fig. 8: The Distribution of Water Quality Index (WQI) at Terengganu River Basin, Terengganu from 2003 until 2009

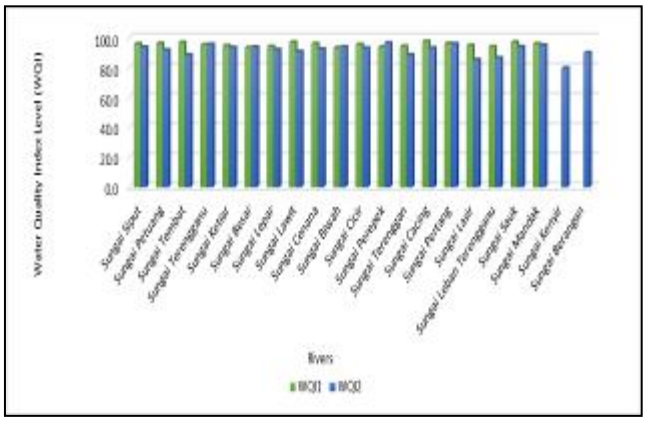

Fig. 9: The Distribution of WQI at Tasik Kenyir, Hulu Terengganu, Terengganu on April 2017 (Dry Season) and December 2016 (Wet Season) at Kenyir Lake Basin, Hulu Terengganu, Terengganu

It is most oftentimes utilized by reference to develop a standard used to determine the water quality corresponding to the health of the ecosystem, security of human contact as well as drinking water. Water quality and quantity standards for surface waters differ notably due to the differences in natural conditions, diversity of ecosystem and variation in human practices. Harmful parameter and high population of specific microorganisms can introduce a wellbeing risk for non-drinking purposes such as recreational activities, irrigation and industrial uses. These conditions may likewise influence the wildlife, which utilizes the water for drinking or as a living space.

Out of six main parameters, four water quality parameters (COD, BOD, TSS and NH3-N) from all the station categories showed statistically no significant difference ($p > 0.05$) (Table 5). Whilst, only two parameters (pH and DO %) show statistically significant differences ($p < 0.05$) for all the station categories. Where all the water quality distribution patterns show the similarity in patterns for all the stations, therefore the sampling design. The selected parameters which include pH and DO % were statistically significant ($p < 0.00001$) which showed the highest mean concentration of concentration distribution during dry season. Table 6 showed all water quality parameters no significantly different ($p > 0.05$) due to their concentration obtained from 21 sampling stations station categories except the DO % ($p < 0.05$). While, the p-value of DO % are lowest than others parameter during wet season. On the other hand, for the future sampling strategy, only the most significant water quality parameters (two) should be taken into consideration for all the sampling station categories.

Table 5: Analysis of variance of water quality parameters sampled from different station category during Dry Season (July 2017) at Kenyir Lake, Hulu Terengganu

Variables	Standard Error	T	P-Value
COD	0.511	-0.858	0.405
BOD	0.531	0.349	0.733
TSS	0.541	-1.742	0.103
NH3-N	0.000		
pH	**0.261**	**5.892**	**< 0.0001**
DO (%)	**0.367**	**6.341**	**< 0.0001**

Table 6: Analysis of variance of pesticide parameters sampled from different station category during Wet Season (December) at Kenyir Lake, Hulu Terengganu

Variables	Standard Error	T	P-Value
COD	1.445	1.207	0.246
BOD	9.671	0.474	0.642
TSS	0.467	0.384	0.706
NH3-N	4.420	-1.696	0.110
pH	1.663	5.160	0.000
DO (%)	**0.105**	**62.542**	**0.023**

*Significance at alpha = 0.05

4.2. Sediment Load Production MS Level

In the normal follow by the hydrological theory, where the discharge value (Q) in the elevated downstream is higher than the upstream. The discharge value (Q) at Sungai Petuang showed the highest values at 10.48 m^3/s (Dry Season) and 29.59 m^3/s (Wet Season), the lowest values at Sungai Bewah with 0.07 m^3/s (Dry Season) and 0.917 m^3/s (Wet Season). The daily suspended sediment production was calculated to estimate the Total Suspended Solid (TSS) tonnes per day (tonnes/day). The highest daily suspended sediment production in a river basin was caused by highest discharge value and the highest TSS, the highest value of estimated TSS (tonnes/day) or suspended sediment load at Sungai Tembat (Dry Season), 12.483 tonnes/day and 14.741 tonnes/day at Sungai Terengganu (Wet Season). In the normal reading through the hydrological theory, where the discharge value (Q) or water velocity in the elevated downstream is higher than upstream and the TSS production higher during the water flow in a basin increased because the higher flow contains the strong energy to move the higher concentrated the suspended sediment load compared to the low flow.

The density of water at forest canopy is the main role towards reducing the surface erosion which contributes to sediment load production in river basin. When the water flow in a basin increased, the TSS will also increase because the higher flow contains the strong energy to move the higher concentrated the suspended sediment load compared to the low flow level and the high water flow also increased the rate of erosion. TSS is also to deter-

mine whether the status of water quality clean, moderately polluted or contaminated and to estimate the suspended sediment load production in the Sungai Terengganu, TSS is an indicator to classify the river in Class I, II, III, IV or Class V, based on NWQS. The highest amount of TSS at Sungai Lepar and Sungai Cenana recorded 18 mg/L respectively. The minimum level amount of TSS at Sungai Besar, 4.4 mg/L during dry season. The value of TSS on dry season showed higher range compared wet season effected by climate changes and anthropogenic factors, the TSS amount for all sampling stations were recorded 4.4 mg/L ± 18.00 mg/L during dry season and 1.6 mg/L ± 15.00 mg/L during wet season (Figure 10 and Figure 11). From the result, the difference amount level of TSS at Kenyir Lake Basin affected by the anthropogenic and geomorphology factors, climate changes and hydrological cycle. This study proved the wet season (higher density of rainfall) caused the higher level of soil loss. From Department of Environment (DOE) 2005 stated the WQI Class of Kenyir Lake Basin for TSS in class II during wets season, the river water needs to be treated and still suitable to protect aquatic species and recreational activities.

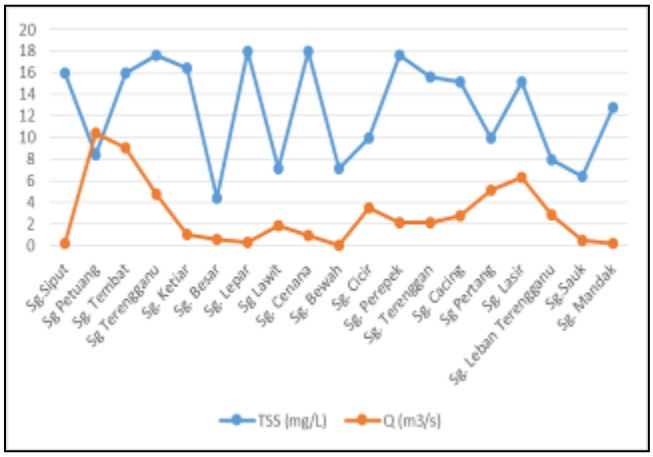

Fig. 10: The Distribution of Total Suspended Solid and River Discharge at Kenyir Lake Basin, Hulu Terengganu during Dry Season (April 2017)

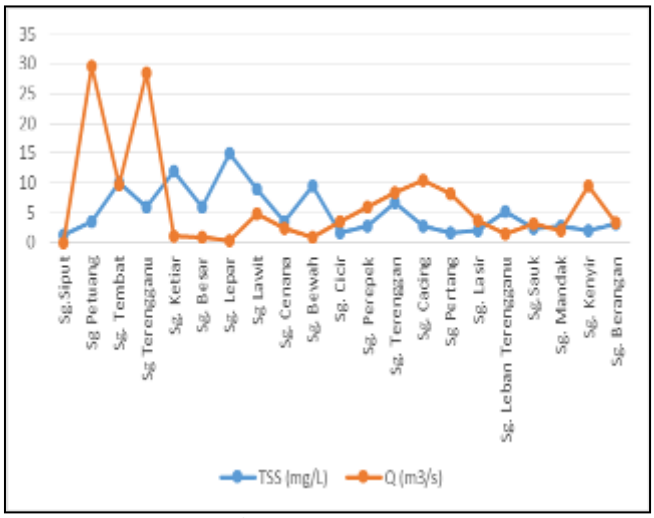

Fig. 11: The Distribution of Total Suspended Solid and River Discharge at Kenyir Lake Basin, Hulu Terengganu during Wet Season (December 2017)

The highest annual suspended sediment load during dry season is 152.493 tonnes/ km^2/year (Station 16) (Sub catchment Sungai Lasir) and the lowest MS value at Station 10 (Sub catchment Sungai Bewah) is 1.829 tonnes/km^2 /year. Meanwhile, the highest MS during wet season was recorded at Station 21 (sub catchment Sungai Berangan) is 83.437 tonnes/km^2 /year and the lowest at Station 15 (sub catchment Sungai Besar) is 3.474 tonnes/km^2/year. Overall, the annual average estimation for annual sediment load production flow out from the tributary rivers into Kenyir Lake is 83.437 tonnes/km^2/year (sub catchment Sungai Berangan) the lowest in the sub catchment Sungai Besar is 2.686 tonnes/ km^2/year (Figure 12). The value of sediment load at downstream and mid-stream of Kenyir Lake higher than upstream. This study proved the impact by the geomorphology, hydrological, development of anthropogenic factors and climate changes such as sand mining activities in Sungai Terengganu Basin and bank erosion along the sub river basin in Kenyir Lake Basin.

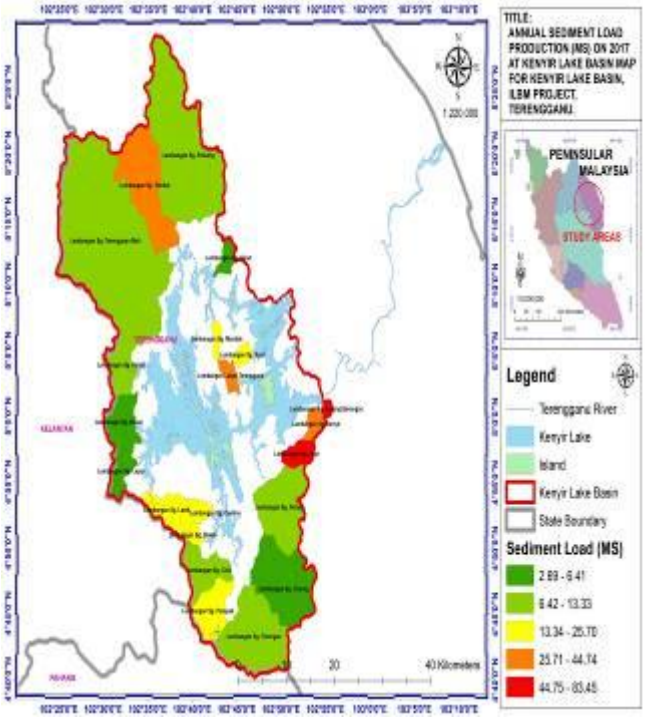

Fig. 12: Map of The distribution of Annual sediment load production (MS) (tonnes/km^2/year) during Wet Season (December 2017) at Kenyir Lake Basin, Hulu Terengganu, Terengganu, Malaysia, 2016.

The simple linear regression model is verified and findings reasonable estimates which generated from the Kenyir Lake prediction of main water quality parameters level. These predications of the water quality parameter using the developed models are in good agreement with observed values. There are low correlation of COD and WQI, TSS and WQI which R^2 = 0.519 and R^2 = 0.5311 respectively during wet season. The production of TSS and COD depends on the others geomorphology, hydrological, climate changes and anthropogenic factors [23, 30]. Besides that, the study proved the correlation between COD, BOD, TSS pH, DO % and WQI during dry season higher significantly ($R^2 > 0.70$) compared wet season. From the value of R^2 = 0.008 and R^2=0.153 showed the sedimentation problems in Kenyir Lake Basin not critically effected to the water quality level (Table 7). One of factor triggered the value of water quality parameter more contributed at downstream and middle stream compared upstream areas, other factors also including such as the dumping garbage and waste domestic from domestic activities and development and which ultimately contaminated the Kenyir Lake [26, 30].

Table 7: Input importance variables in linear relationship (linear regression) to predict water quality index (WQI) on Dry Season and Wet Season at Terengganu River Basin, 2016

	COD (mg/L)	BOD (mg/L)	TSS (mg/L)	NH3-N (mg/L)	pH	DO (%)	MS
R^2 (Dry Season)	0.95	0.87	0.76	-	0.73	0.75	0.008
R^2 (Wet Season)	0.519	0.810	0.531	0.858	0.734	0.826	0.153

5. Conclusion

Overall, the water in the Kenyir Lake classified under Class I during dry season and a few sampling station recorded under Class II especially nearby active development and climates changes during wet season. Sedimentation issues have to be taken into account when implementing the landuse and development plan surrounding the reservoir area in order to control sedimentation in Kenyir Lake Basin. Advisable to develop buffer zone areas act for all tributary and water body areas and construct bank protection project with soft engineering method at erosion potential areas to decrease the erosion problem which will lead to deposited sediment. Flow conditions in the reservoir also need to be created and stabilized to control the deposition of sediment. The monitoring of the current reservoir sedimentation, future sediment inflow and also the deposition analysis. This sedimentation problems level in the Kenyir Lake Basin is not in critically stage but it will be contributed to the increasing levels of sedimentation if the development activities in uncontrolled rate. From the study, it is clear that stations (downstream and middle stream) more polluted than other sampling stations which mostly at upstream area due to land use activities. The main sources of pollutants were possibly waste products and waste from development activities around Kenyir Lake Basin and Natural Park such as tourism, construction and residential.

Acknowledgement

Tenaga Nasional Berhad (TNB) Research funded this research through a research grant (grant number: 1-1017-0006). The authors would like to thank TNB Research for the research grant and SRGS grant: Pembangunan Pemodelan Luahan Persekitaran Ekohidrologi di Tasik Kenyir, Hulu Terengganu,Terengganu. (UniSZA/2017/SRGS/17) – R0019-R017., Department of Irrigation and Drainage Malaysia for the secondary data and East Coast Environmental Research Institute (ESERI), Universiti Sultan Zainal Abidin (UNISZA) give permission to use research facilities and supporting in this research.

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