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ASSESSMENTS OF LAKE PROFILING ON TEMPERATURE, TOTAL SUSPENDED SOLID (TSS) AND TURBIDITY IN THE KENYIR LAKE, TERENGGANU, MALAYSIA

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ABSTRACT

Spatial interpolation method of water quality evaluation are frequently used to estimate valuation Kenyir Lake profiling used regression analysis and Geographic Information System (GIS) to assess a few of the water quality classification at Kenyir Lake. The purpose is to investigate the relative performance of different interpolation methods in surface waters. The study archived data from the Kenyir Lake using spatial interpolation of inverse distance weighting (IDW), which incorporates output from a process-based regression model.

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Interpolation were performed on temperature, total suspended solid (TSS) and turbidity (TUR) based on in-situ and ex-situ analyses according to the correlation matrix and linear regression at 14 different depths for the Chomor River and Mahadir Island. The result showed outlet significantly decreased over depth caused the water quality deterioration of Kenyir Lake development.

Keywords: lake profiling; inverse distance weighting; total suspended solid (TSS); Interpolation; geographic information system (GIS).

1. INTRODUCTION

There are many interpolation or prediction techniques exist and used in water quality studies such as in this research about the spatial interpolation method at the Kenyir Lake. It has stimulated several comparative studies of interpolation accuracy [1-3]. The existing research tends to be one of the interpolation technique is the most accurate. Many different spatial interpolation methods have been developed, including both stochastic or statistical methods such as kriging and non-statistical methods such as inverse distance weighting (IDW). Basically, the stochastic methods are referred to as spatial prediction such as non-statistical methods frequently are called spatial interpolation [4]. According [5] indicated that kriging yielded better estimations of altitude than inverse distance weighting (IDW) and an irrespective of the landform type and sampling pattern. The ability of kriging can take into account the spatial structure of data. However, in other studies [1, 6-9] there are approaches such as IDW or radial basis functions were as accurate as kriging or even better.

The kriging methods generally outperform inverse distance weighting for all parameters and depths. Incorporating output from the water quality model through universal kriging appears to improve some of the interpolations. Such integration of process-based information with statistical interpolation warrants further study. By using Geographic Information System (GIS) software such as ArcGis can help this studies to view the details of information. For lab profiling of Kenyir Lake at Terengganu, Malaysia used Inverse Distance Weighting (IDW) by using two stations which are Chomor River and Mahadir Island. It is moderately quick and simple to register and clear to interpret. The IDW will view the range and pattern of the temperature, TSS and TUR for each depth (10m-140m) by map using GIS software. The management and control must be conducted to address and solve these issues around Kenyir Lake especially ecotourism areas [10].

2. METHODOLOGY

This study was conducted in Lake Kenyir which one of the ecotourism areas in Malaysia and the largest man-made lake in South East Asia with a surface area of about 36,900 hectares. It lies at latitude 4° 41’ north and longitude 102° 40’ east and receiving water inputs from main rivers, the Terengganu River Basin [11]. The main reason of this lake was constructed for the purpose of generating hydroelectric power which is able to supply electricity to all state in Peninsular Malaysia. The construction of the dam around Kenyir Lake started from 1978 and was completed in 1985. The lake has an average depth of 37 meters with a maximum depth of 145 meters. There are 340 islands in the lake, more than 14 waterfalls and numerous rapids and rivers. There have beautiful landscape and the surrounding natural environment provide a pleasant recreational [12]. Kenyir Lake is a one of famous lake in Terengganu and Peninsular Malaysia which fascinating tourist spot with its offering of waterfalls, limestone caves and a lush tropical forest which is home to more than 8,000 species of flowers, 2,500 species of plants and trees and 300 species of fungus [13-14].

Kenyir Lake is a reservoirs in Peninsular Malaysia that need serious attention in its management and conservation of water quality and sedimentation level. There are 2 stations that will be interpolate in the Kenyir Lake,Terengganu which are Chomor River and Mahadir Island. The location for both sampling point for Chomor River and Mahadir Island (Table 1) and the projection for both location is Rectified Skew Orthomophic (RSO) Kertau Malaya (meter) which is the most suitable for Malaysia [15].

Table 1. Location of the sampling stations at Kenyir Lake

Sampling Stations	Latitude	Longitude
Chomor River	N 05°00' 59.9"	E 102°51' 14.3"
Mahadir Island	N 04°58' 52.8"	E 102°43' 58.5"

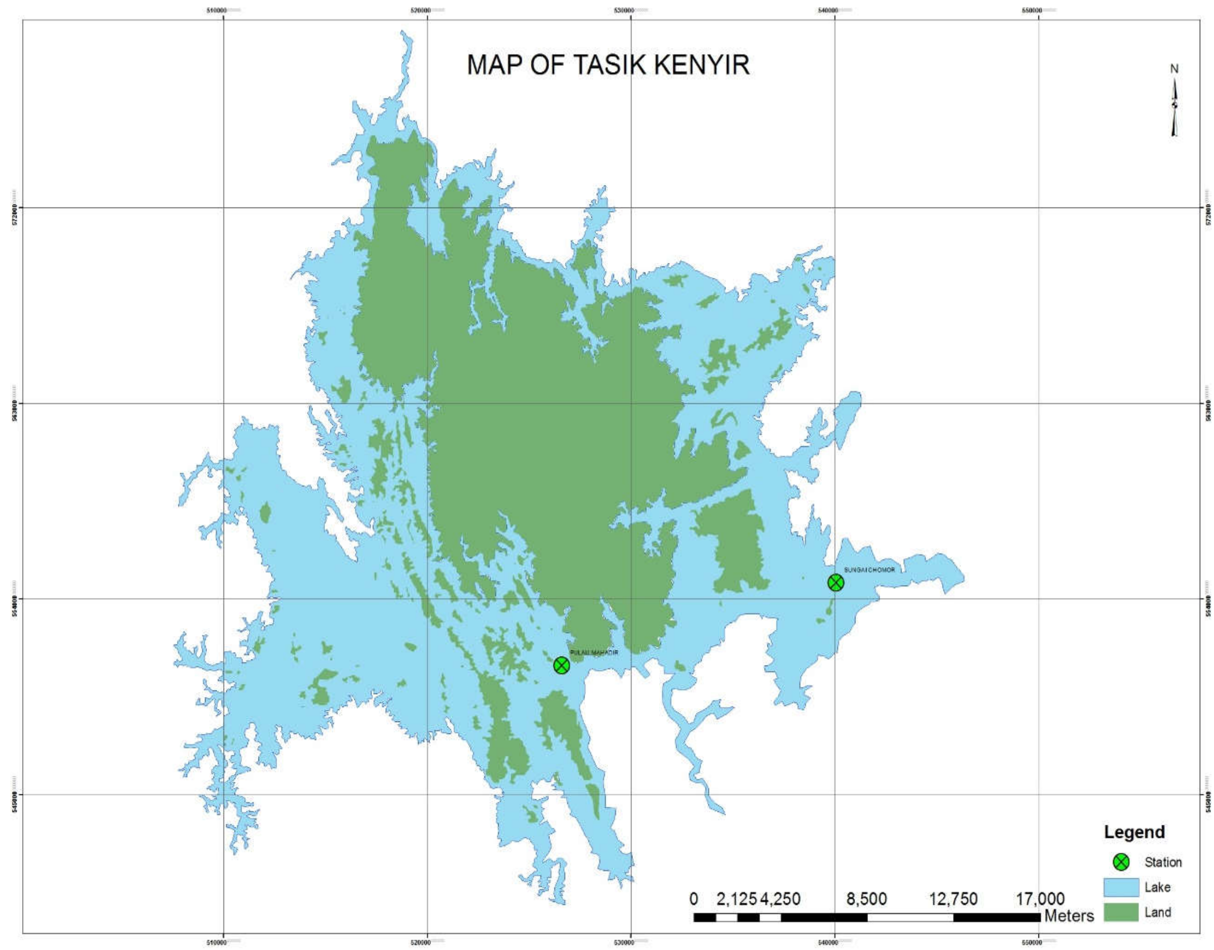


Fig.1. Location of sampling station sat Kenyir Lake

All water samples for each depth (10m-140m) from two stations (Chomor River and Mahadir Island) were conducted following the procedures by United States Environmental Protection Agency (USEPA) methods, especially for total suspended solid (TSS) measurement. The measurement of in situ parameters such as temperature and turbidity (TUR) were determined by using the water quality Multiprobe YSI 58 and Turbidity Portable Meter. These tools were calibrated before field sampling. The Gravimetric method was used to analysis the TSS measured in mg/L. In lab analysis, about 250 ml water sample for each depth from two stations (Fig. 2a). TSS measurement was performed by weighing the membrane filter paper 0.45µm one by one and the reading was taken (Fig. 2b). Firstly, weighing the membrane filters using electronic weighing (Fig. 2c). Next, the membrane filter was placed onto a filtration apparatus (Nalgene, U.S.A) which connected to a vacuum pump and clipped in place (Fig. 2d). After that, the water sample lowly poured into the filtration jar, the membrane filter was removed and allowed to dry in the drying jar. Once the membrane filter paper is dried, it is weighed to get the reading (Fig. 2e). TSS is measured by mg/L unit based on (Equation (1)). For precaution steps must be taken during the water sample for TSS analysis, the interference of water flow should be minimum to prevent the deposition of the suspended sediment [16].

(a) (b) (c) (d) (e)

Fig.2. a) Sample water b) Membrane filter c) Electronic weighing d) Filtration apparatus connected to a vacuum pump (Nalgene, U.S.A) e) Dry membrane filter

2.1. Total Suspended Solid (TSS)

TSS = {(WBF+ DR) - WBF} (mg) x 1000 / VFW (mL)

= mg/L/1000/1000/1000

= tonne/L (1)

*WBF = Weight of membrane filter; DR = Dry residue; VFW = Volume of filtered water [17]

2.2. Inverse Distance Weighting (IDW)

IDW interpolation combines the idea of proximity espoused by Thiessen polygons [18] with the gradual change of a trend surface or depth of lake. Those measured values closest to the prediction location will have more influence on the predicted value than those farther away. IDW assumes that each measured point has a local influence that diminishes with distance. The usual expression is (Equation (2)):

$$\hat{Z}(s0) = \left[\frac{\sum_{i=1}^{N} [\![w(di)]\!] Z(si)}{\sum_{i=1}^{N} [\![w(di)]\!]}\right] \quad (2)$$

where ˆ Z(s0), Z(si) represent the predicted and observed value at location s0, si, N is the number of measured sample points used in the prediction, w(d) is the weighting function and di is the distance from s0 to si . In case of this study that mean ˆ Z (s0), Z (si) is the parameter measured that have been predicted and observed at 2 stations which are Sungai Chomor and

Mahadir Island as s0, si, N is the depth that heve been taken from the study area then w(d) is its weighting function and di is the distance from the station (s0 to si). Based on the structure of IDW expression, the choice of weighting function can significantly affect the interpolation results. The comparative merits of various weighting functions are discussed in detail [19]. The IDW parameters specified in ArcGIS are the power option, search shape, search radius and number of points.

3. RESULTS AND DISCUSSION

The interpolation method for both station at Kenyir Lake will viewed on each parameter which are temperature (°C), total suspended solid (TSS) (mg/L) and Turbidity (TUR) (NTU). The different of depth (10m until 140 m) will produce different parameters level and difference value of its range. Further work is underway to take further advantage of available data and tools for Kenyir Lake interpolation. Kenyir Lake depth is decreasing due to sediment input from erosion process and the bottom composition is a mixture of inorganic sediment and rich organic matter washed in from the highly productive drainage areas. Result of the temperature, TSS and TUR for 10m until 140m surface samples from Kenyir Lake (Chomor River and Mahadir Island) are tabulated in (Fig. 3 and Fig. 4). The deeper parts of the sampling locations have different distribution of temperature, TSS and TUR. There are likely explanations for the relatively poor performance of all three interpolation schemes.

The range distribution of temperature, turbidity and TSS respectively 26.90°C ± 22.91°C (Chomor River) and 28.02°C ± 5.59°C (Mahadir Island), 2.36 NTU ± 13.36 NTU (Chomor River) and 2.33 NTU ± 23.70 NTU (Mahadir Island), 24.44 mg/L ± 22.06 mg/L (Chomor River) and 11.658 mg/L ± 24.925 mg/L (Mahadir Island). The minimum value of temperature at Chomor River bigger than Mahadir Island and there are larger gap between minimum (5.59°C) and maximum (28.02°C) value of temperature at Mahadir Island. The minimum and maximum value of TUR at Chomor River and Mahadir Island, 2.36 NTU and 2.33 NTU, 13.36 NTU and 23.70 NTU respectively. There are larger gap between minimum and maximum value of TUR at Mahadir Island compared Chomor River. TSS values higher trends followed by deeper of depth at Mahadir Island compares Chomor River. Chomor River was located to the settlements of the indigenous people at the Kenyir Lake and more subject to contamination by organic substances on water surface was detected from the values of TSS. There are smaller gap between the minimum and maximum values of TSS compared to Mahadir Island. Overall, the TSS concentrations recorded in the study area were low.

(Fig. 5, Fig. 6 and Fig. 7) showed the map of temperature, TSS and TUR for 10m-140m at Chomor River and Mahadir Island. From the result, the IDW method used to analyze the distribution of water quality parameter based on the depth of lake and the spatial interpolation is the process of using points with known values to estimate values at other unknown points. This type of interpolated surface is often called a statistical surface. Water with high TSS is unpalatable and potentially unhealthy. The INWQS maximum threshold levels of TSS for Malaysian surface water ranges from 25 to 50 mg/L. The INWQS threshold level of TSS for supporting aquatic life in fresh water ecosystems is 150 mg/L.

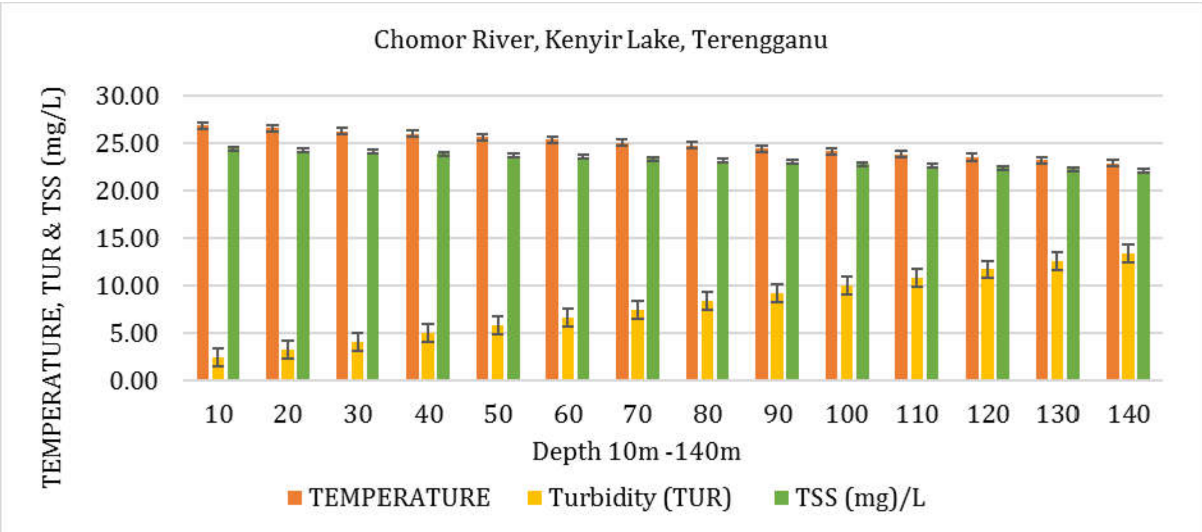


Fig.3. Distribution of Temperature, Turbidity (TUR) and Total Suspended Solid (TSS) (mg/L) Based on Depth at Chomor River, Kenyir Lake, Terengganu

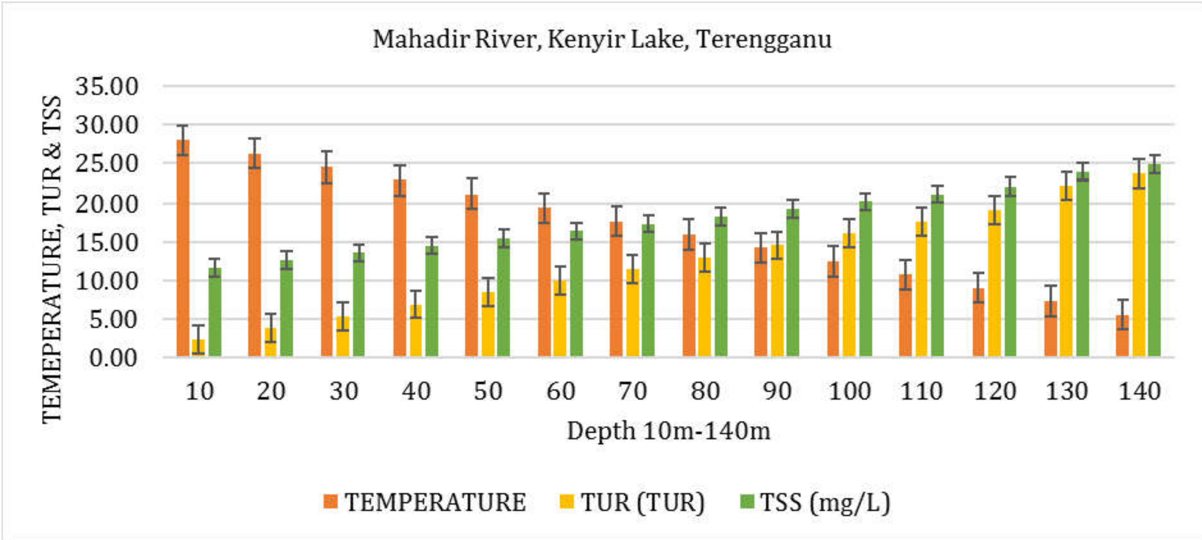
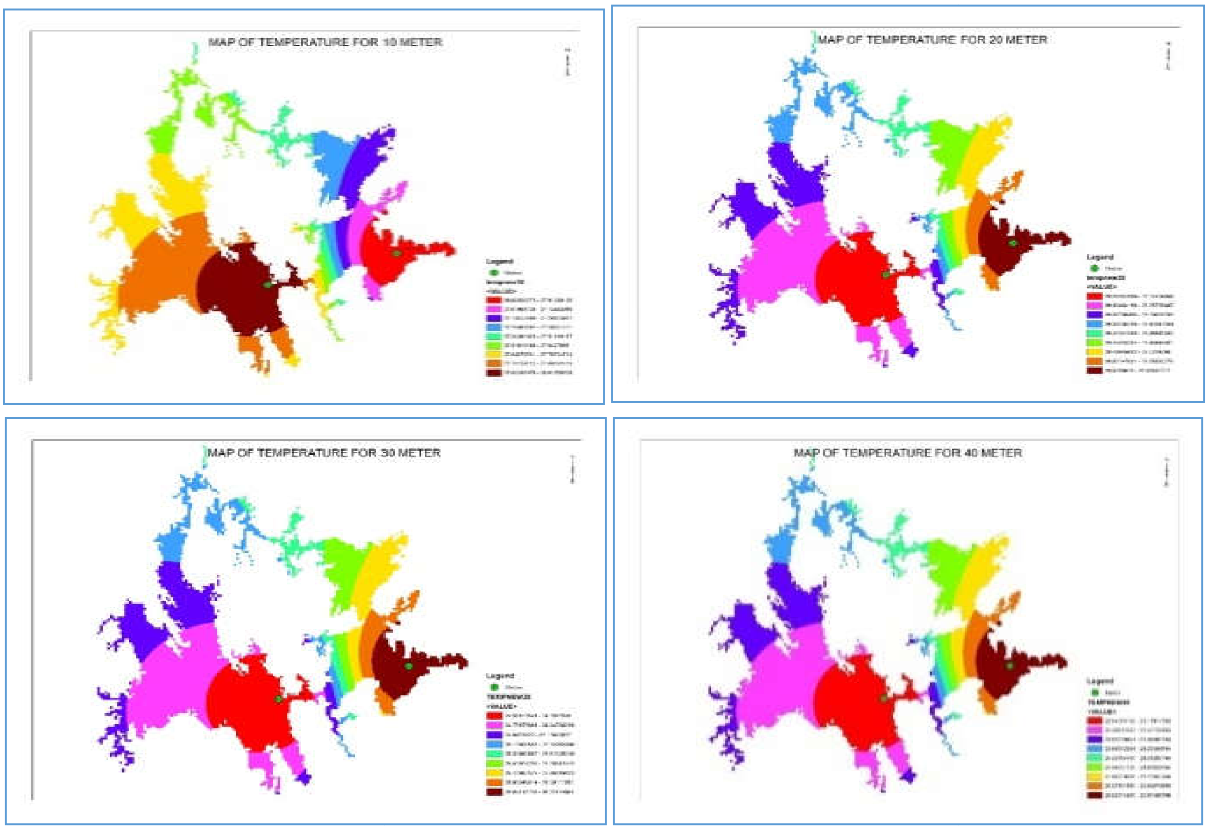
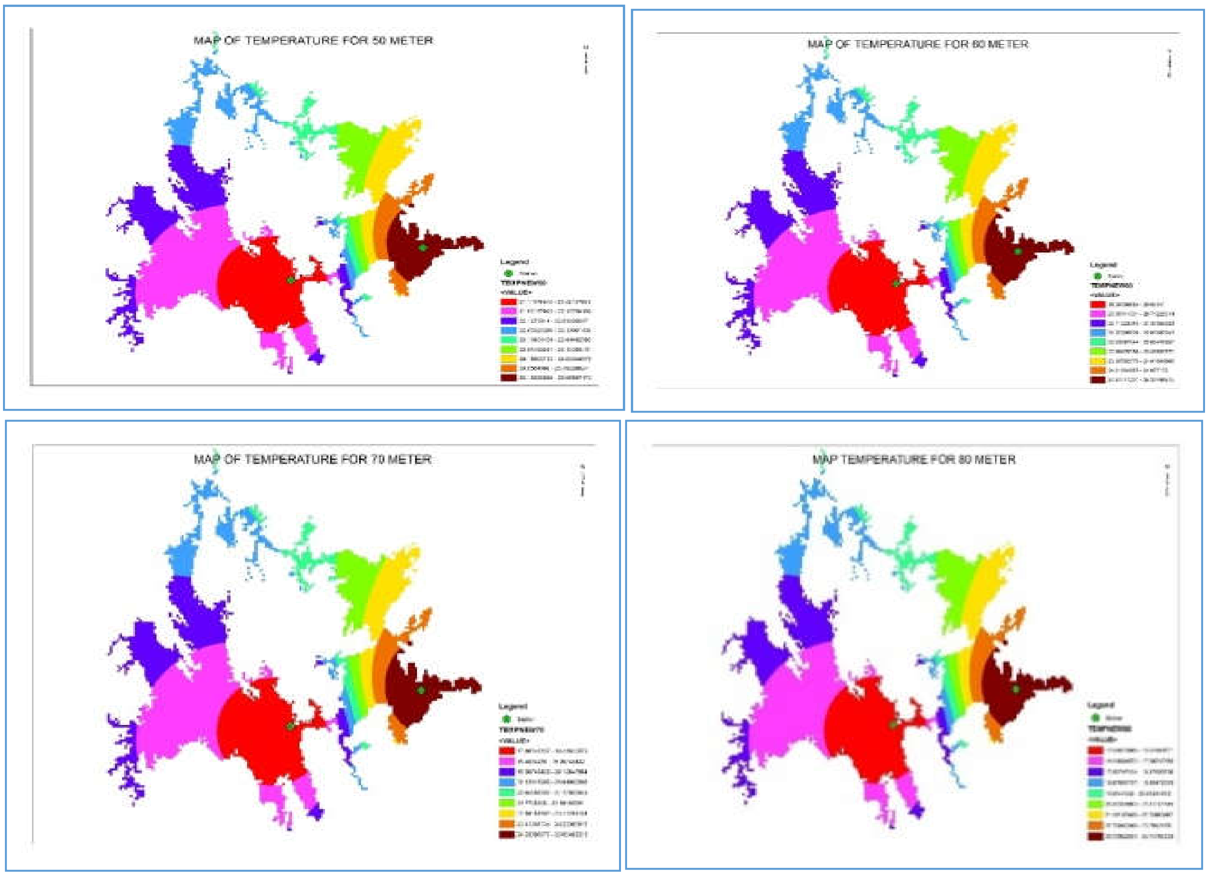


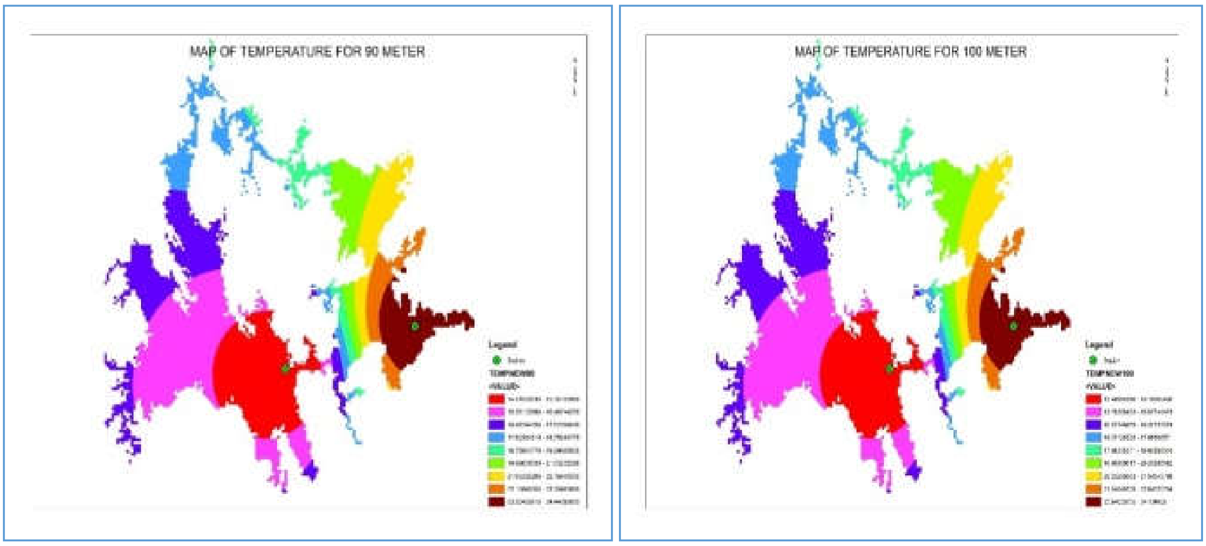
Fig.4. Distribution of Temperature, Turbidity (TUR) and Total Suspended Solid (TSS) (mg/L)

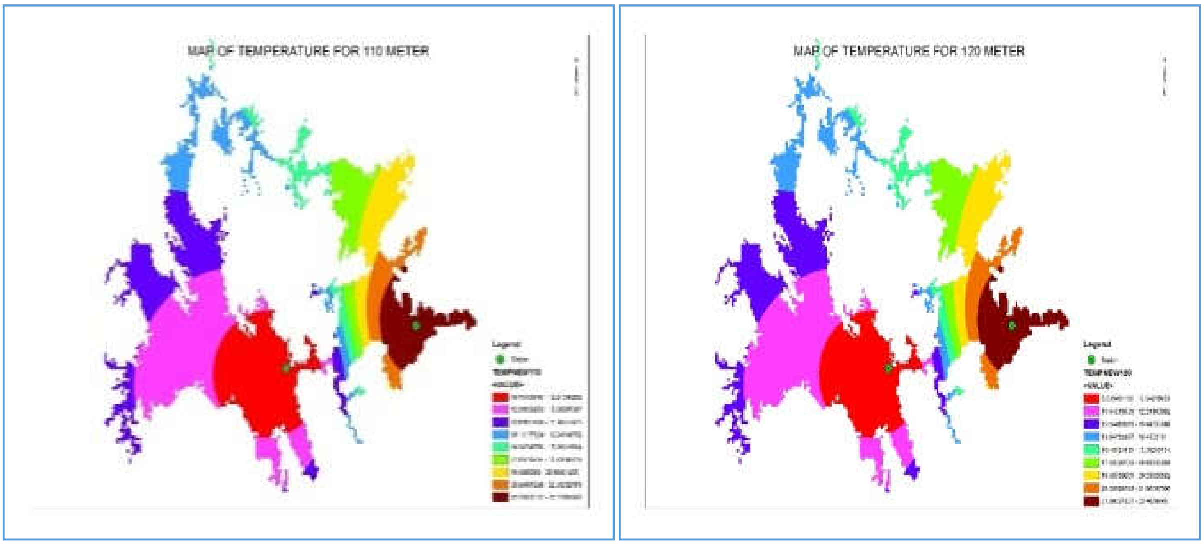


Map of temperature for 10m-40m

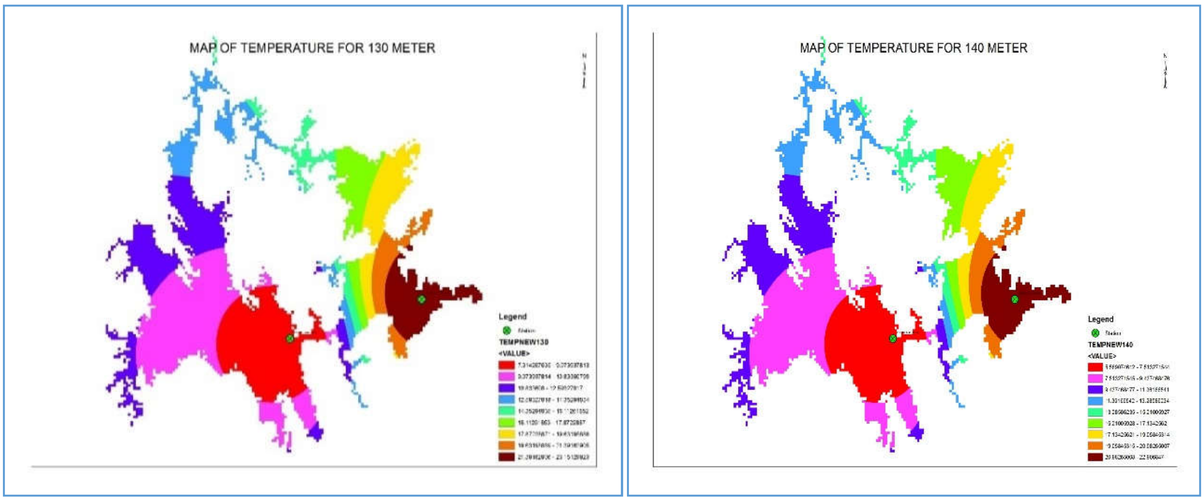


Map of temperature for 50m-80m



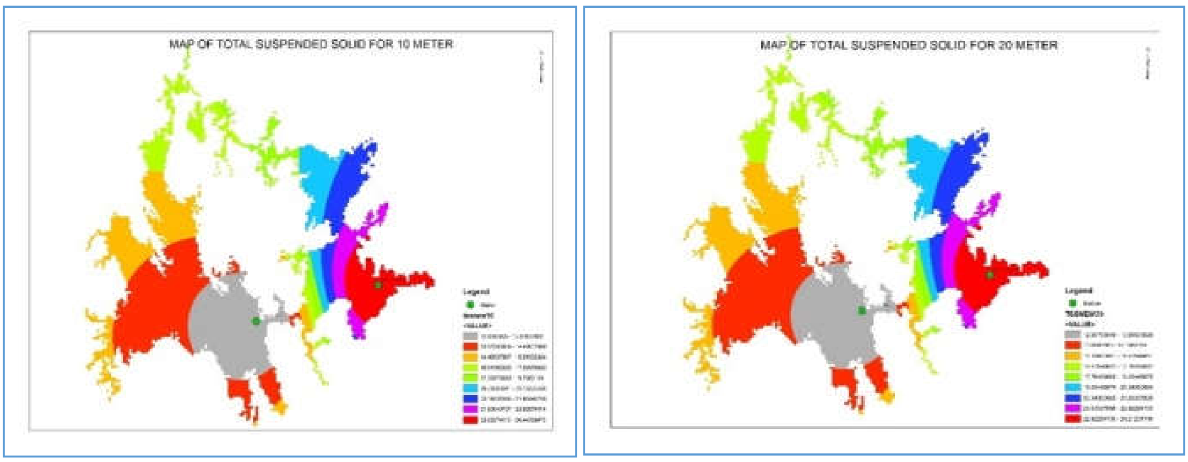


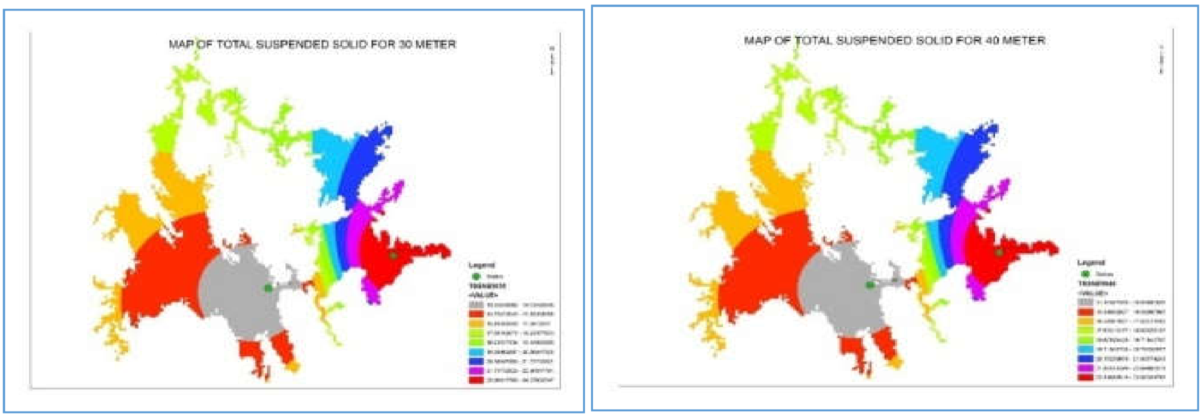
Map of temperature for 90m-120m



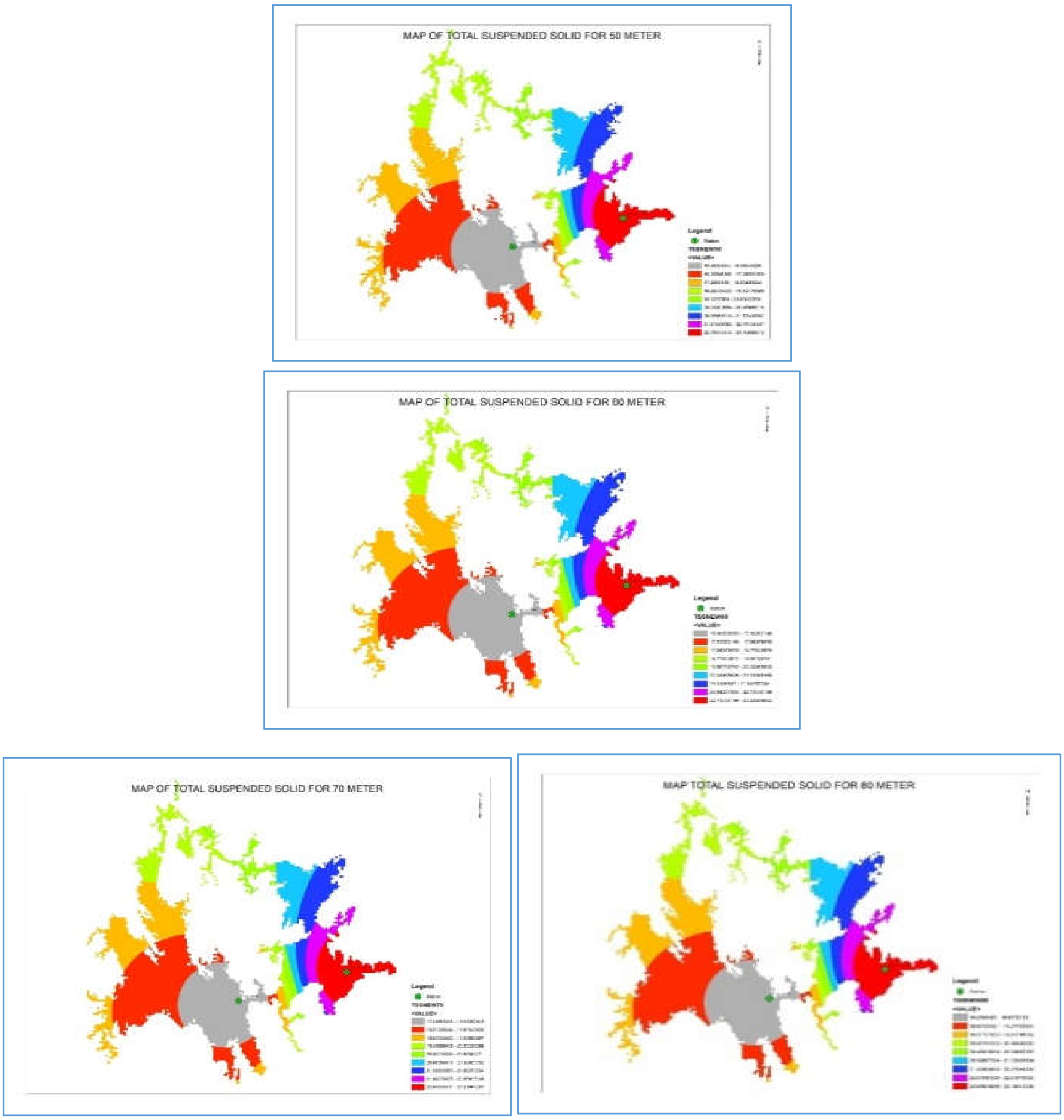
Map of temperature for 130m-140m

Fig.5. Map of temperature for 10m-140m at Mahadir Island and Chomor River, Kenyir Lake, Terengganu

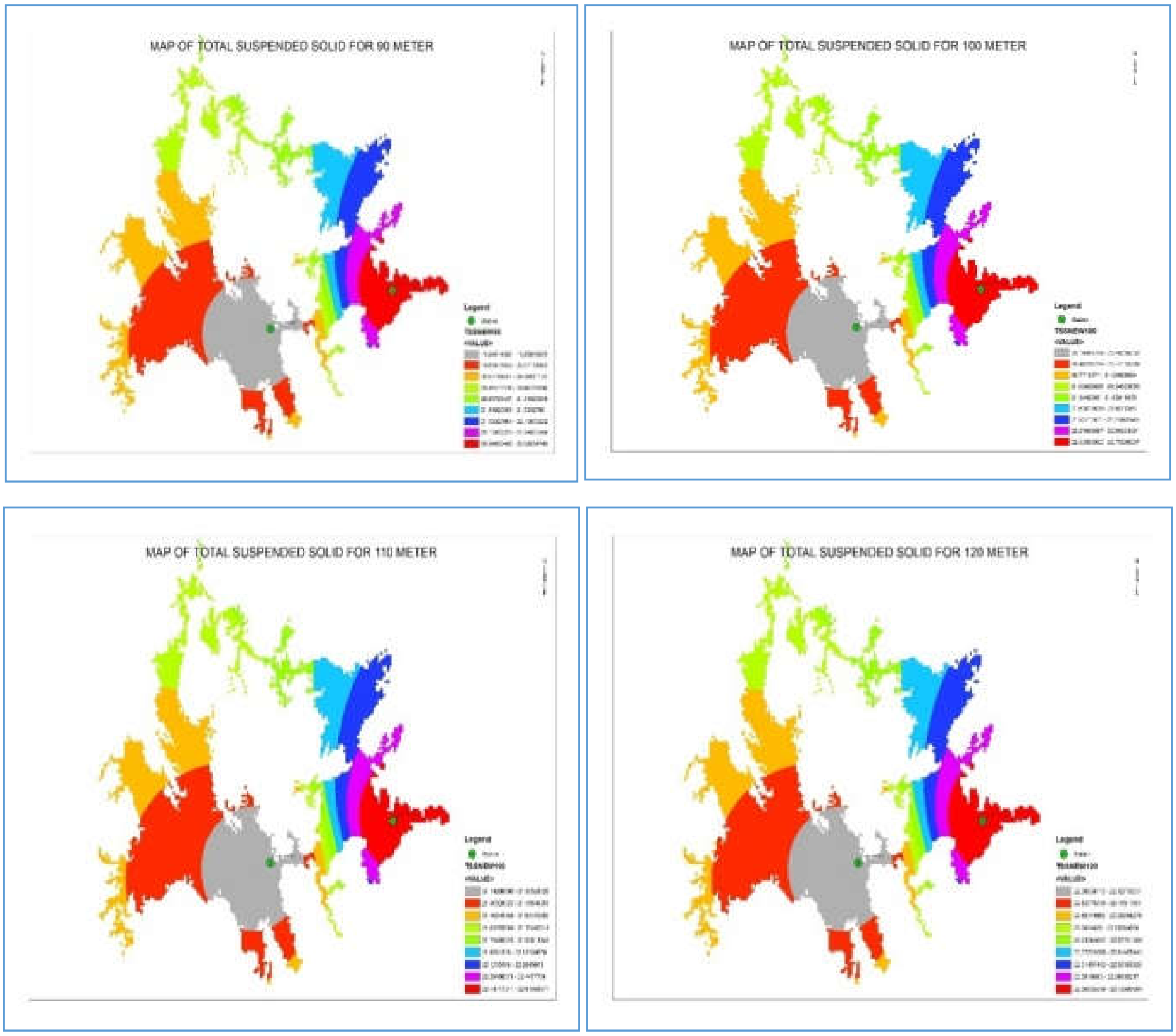




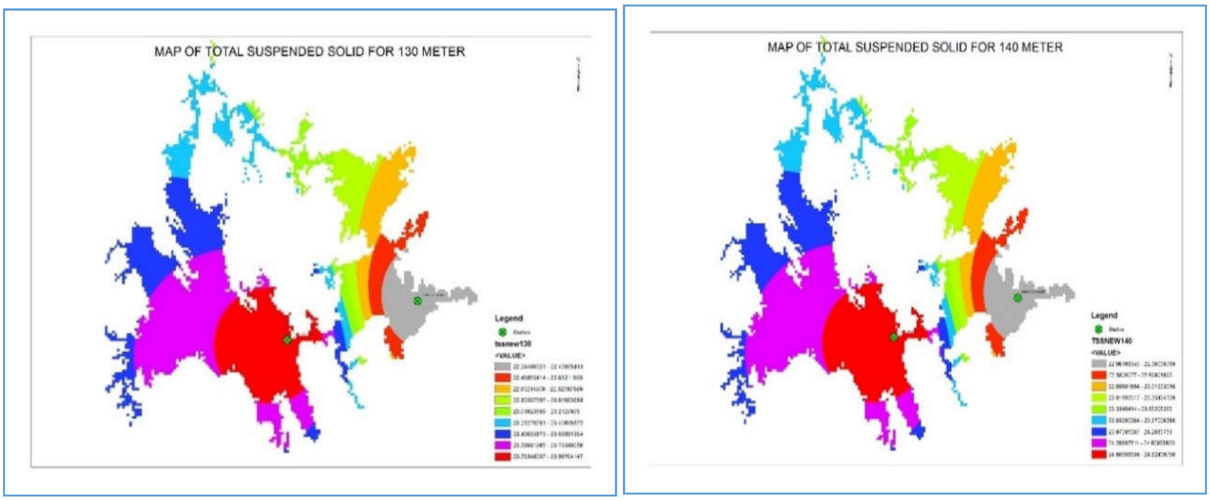
Map of Total Suspended Solid (TSS) for 10m-40m



Map of Total Suspended Solid (TSS) for 50m-80m

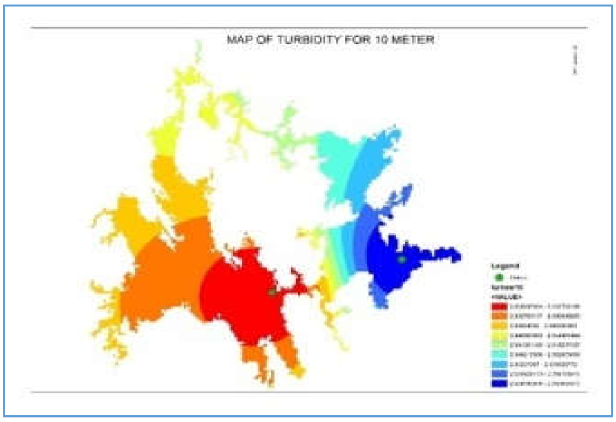


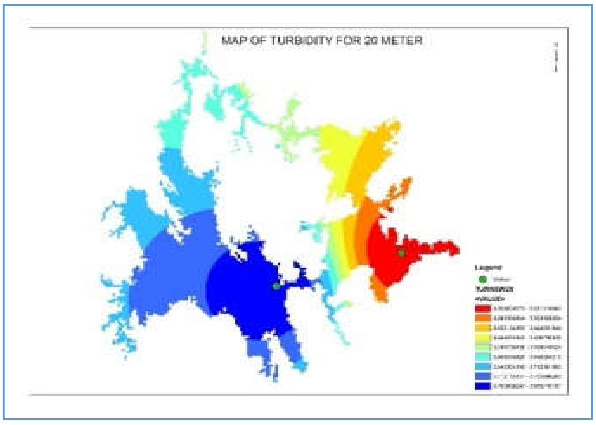
Map of Total Suspended Solid (TSS) for 90m-120m

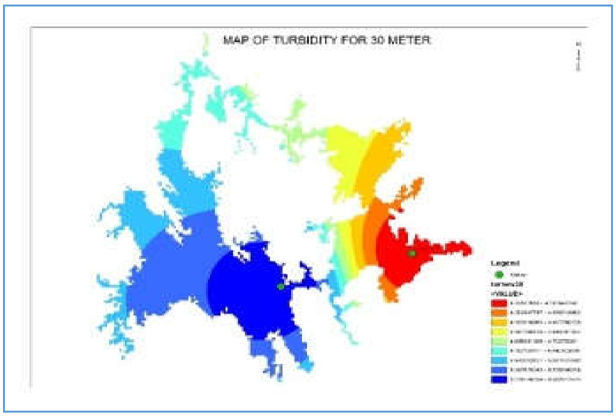


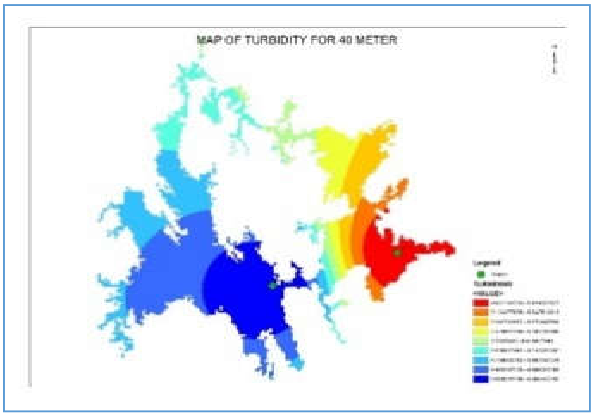
Map of Total Suspended Solid (TSS) for 130m-140m

Fig.6. Map of Total Suspended Solid (TSS) for 10m-140m at Mahadir Island and Chomor River, Kenyir Lake, Terengganu

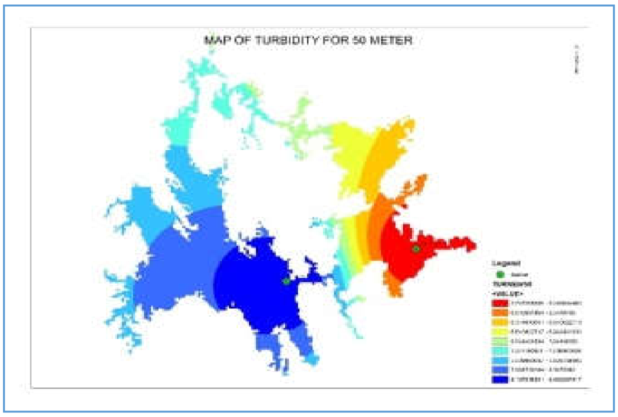


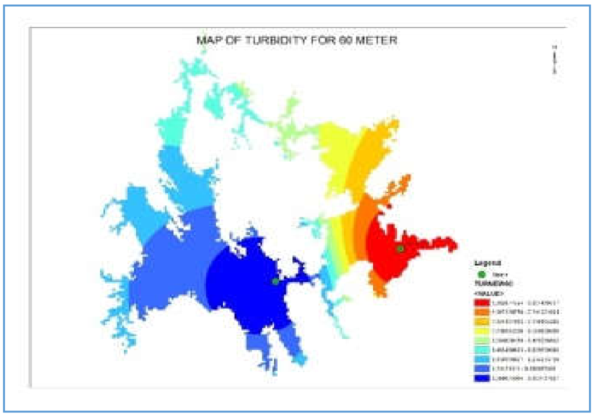


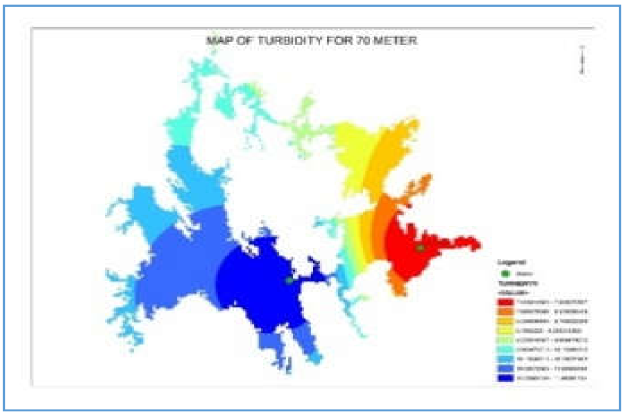


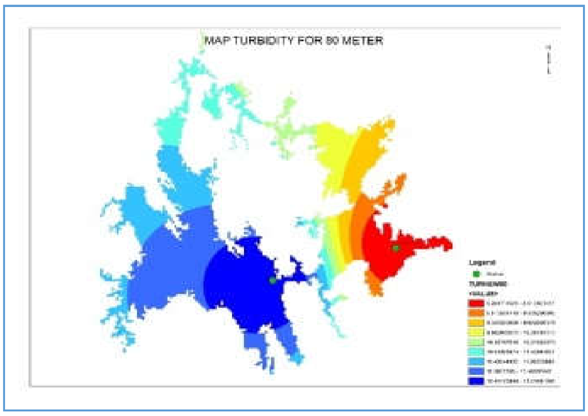


Map of Turbidity (TUR) for 10m-40m

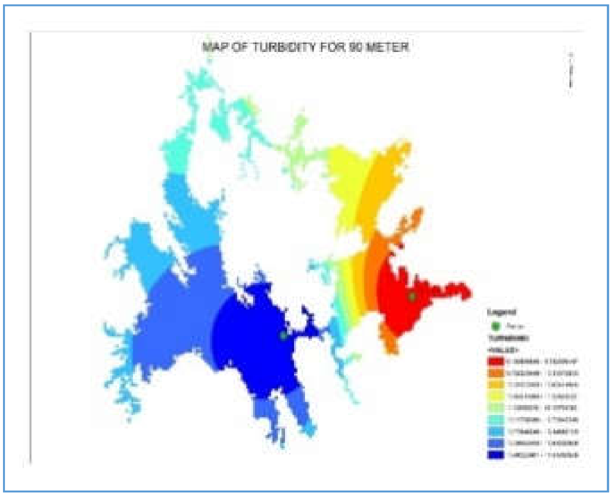


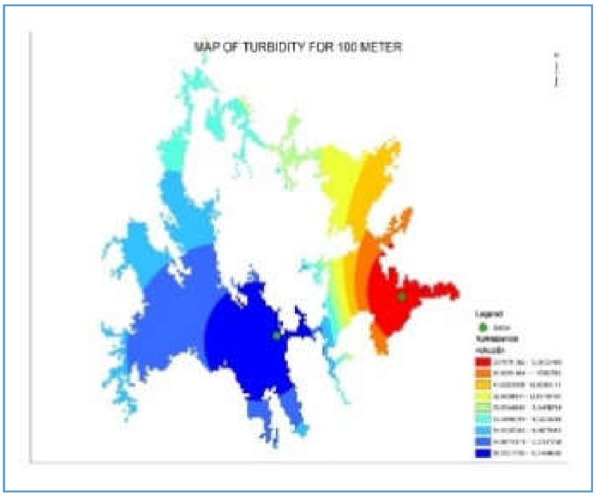


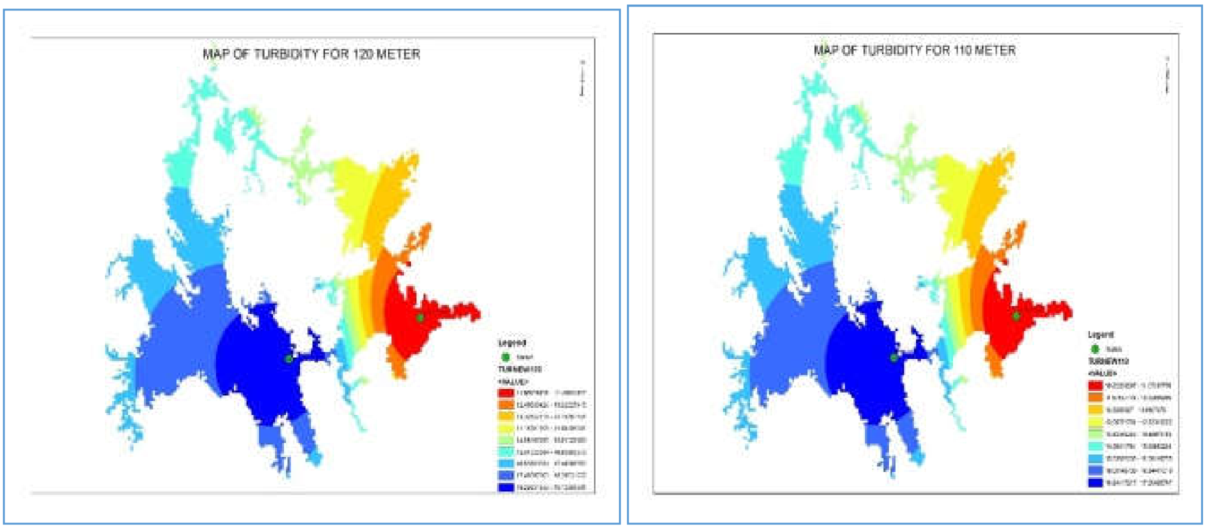




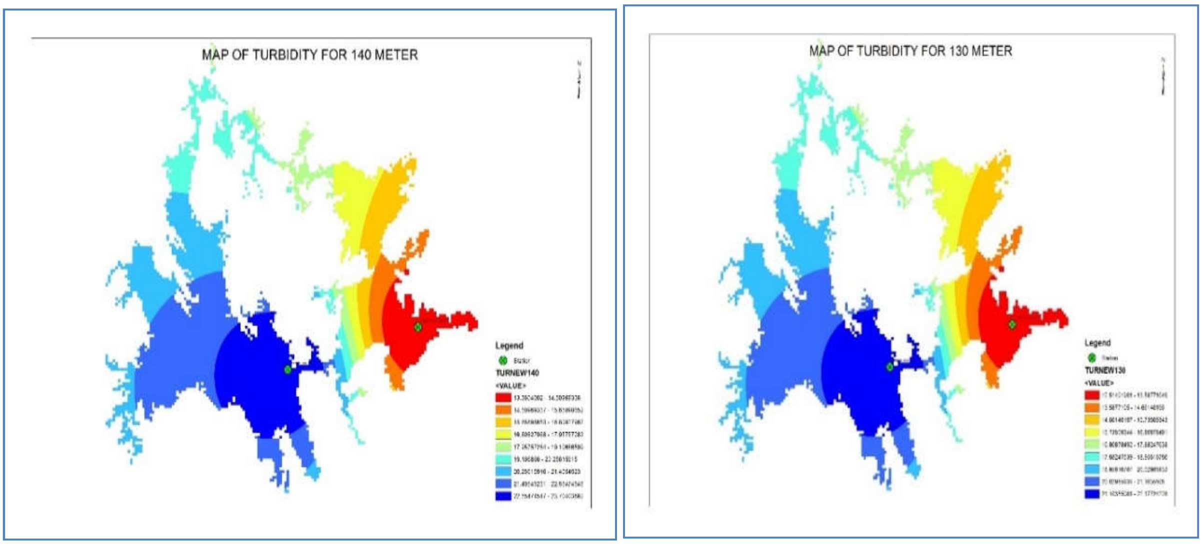
Map of Turbidity (TUR) for 50m-80m







Map of Turbidity (TUR) for 90m-120m

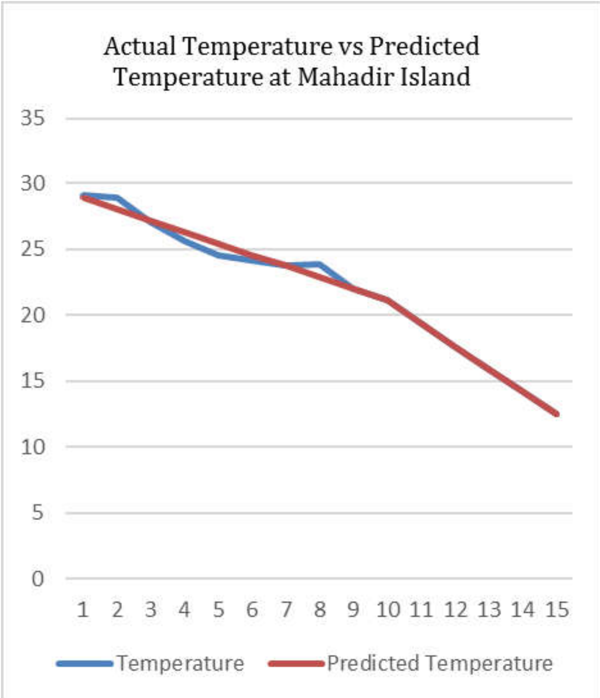


Map of Turbidity (TUR) for 130m-140m

Fig.7. Map of Turbidity (TUR) for 10m-140m at Mahadir Island and Chomor River, Kenyir Lake, Terengganu

Fig. 8, Fig. 9 and Fig. 10 showed the comparison between the actual temperature, TSS, TUR and predicted temperature, TSS and TUR for two location at Kenyir Lake on 2016 based on the depth of lake (10m-140m). The result showed the actual and predicted value of temperature at Mahadir Island and Chomor River have no significant difference. There are higher actual value of TSS of both sampling location than predicted level especially at 50m (Mahadir Island) and 100m (Chomor River). Besides that, the actual value of TUR higher than predicted value at 50m- 60m for Mahadir Island and 70m-90m for Chomor River. The management and control approach must be conducted to improve the water quality deterioration were possibly waste product and effluent, which from development and activities in the Kenyir Lake that ultimately contaminated the river basin.

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 Terengganu River basin. 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 downstream and middle stream stations, which around industrial, farming, sand mining and residential area.



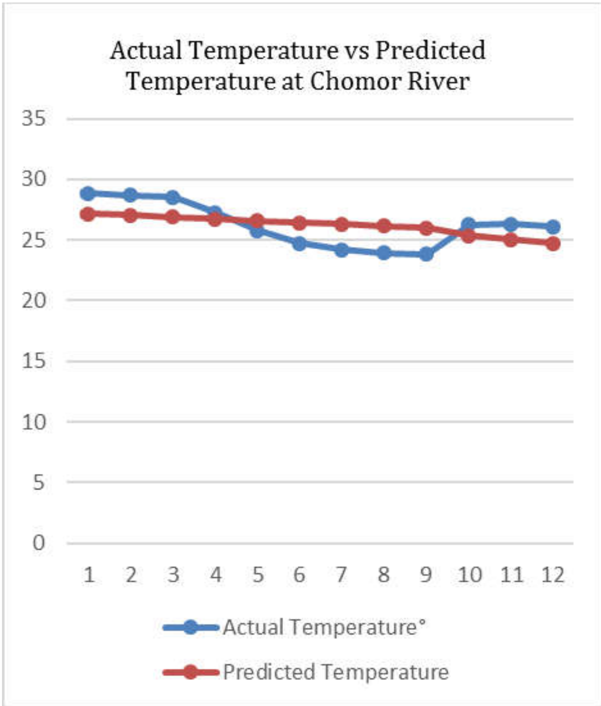


Fig.8. Actual temperature versus predicted temperature at Mahadir Island and Chomor River, Kenyir Lake, Terengganu

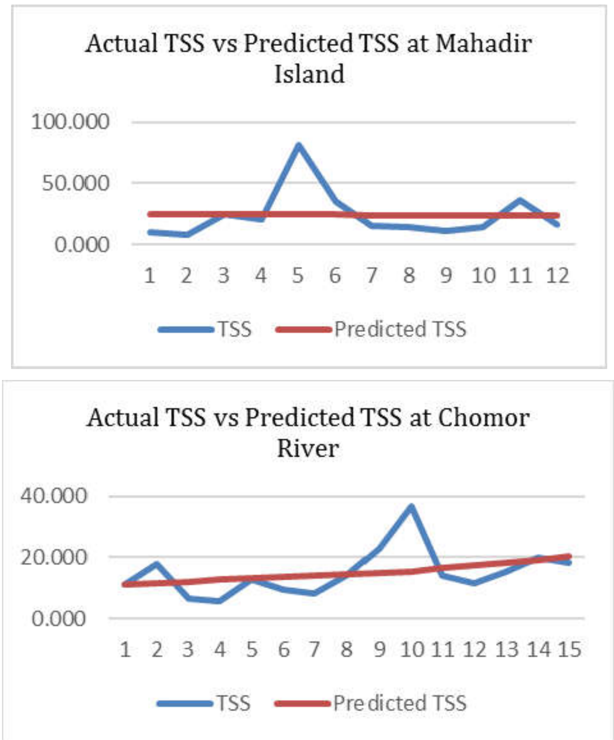


Fig.9. Actual Total Suspended Solid (TSS) versus Predicted Total Suspended Solid (TSS) at Mahadir Island and Chomor River, Kenyir Lake, Terengganu

Following regression equation is used to established correlation between parameters for Mahadir Island and Chomor River (Equation (3)-Equation (8)):

Mahadir Island:

Temperature = 29.74179-0.17252*Depth (3)

TSS = 10.71043+0.09483*Depth (m) (4)

Turbidity = 123.91071-0.32381*Depth (5)

Chomor River:

Temperature = 29.74179-0.17252*Depth (6)

TSS = 24.623-1.8298*Depth (7)

Turbidity = 123.91071-0.32381*Depth (8)

Therefore, this study proposed regression models of water quality parameter which estimated three parameter for contrast, correlation and comparison of actual and predicted values. The predictive model with best correlation will be used later in the classification and identification of actual and predicted values. The models are verified and found to provide reasonable estimates which generated from the Kenyir Lake. The predications of the water quality parameter using the developed models are in good agreement with observed values.

However, it is observed that temperature, total suspended solid and turbidity are over predicted by the models [20-21]. There are high significant relations of $R^2 = 0.991$ and $R^2 = 0.9070$ shows in (Fig. 10 and Fig. 11). This correlation showed a high positive relationship between temperature and depth. Increase in depth caused an increase in temperature for both location, but this result proved there are low significant relation of TSS and depth which $R^2 = 0.131$ and $R^2 = 0.001$ respectively. The depth not as main factor the increased of TSS. From this research, the production of TSS not only depends on the depth but also depends on the others geomorphology, hydrological and anthropogenic factors. Besides that, the study proved the correlation between TUR and depth at Chomor River ($R^2 = 0.9514$) more significantly compared Mahadir Island ($R^2 = 0.794$). One of factor triggered the value of TUR 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.

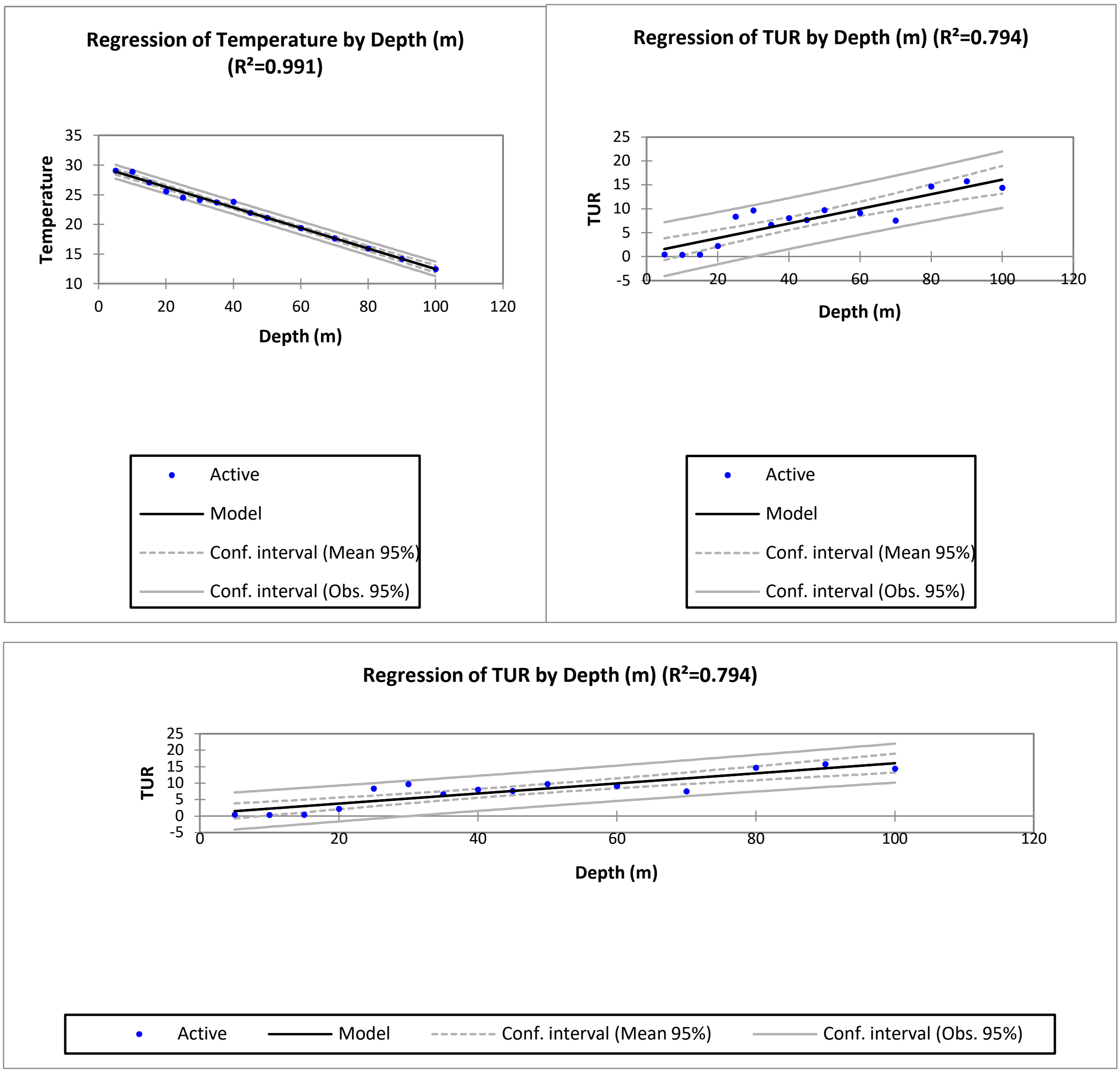
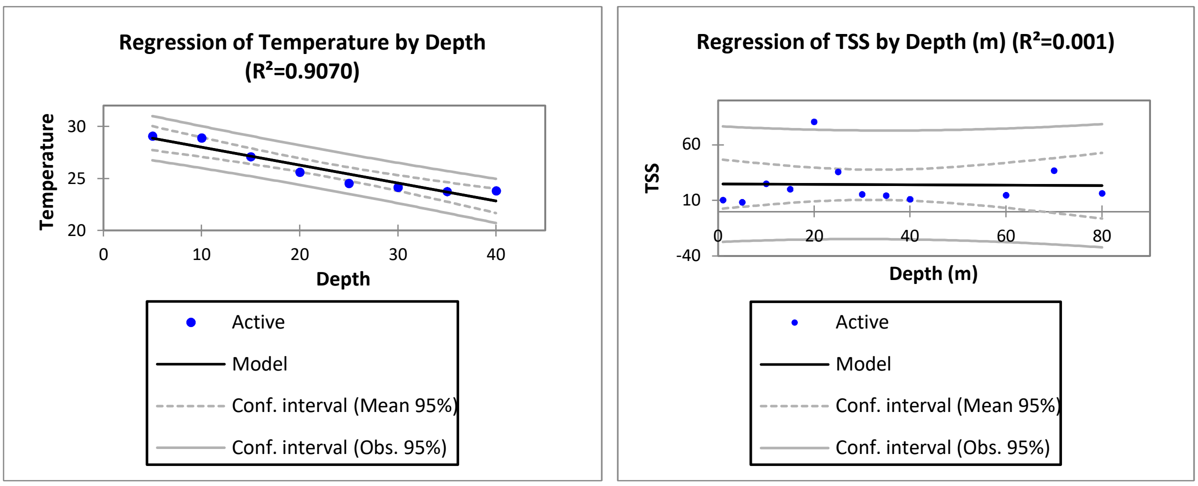


Fig.10. The regression of depth with temperature, Total Suspended Solid (TSS) and Turbidity at Mahadir Island, Kenyir Lake, Terengganu



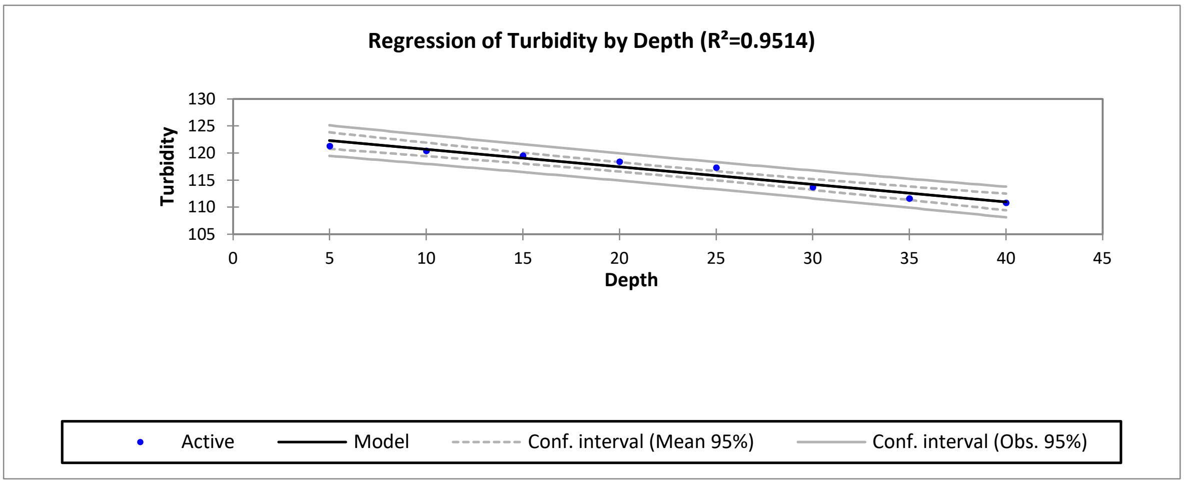


Fig.11. The regression of depth with temperature, Total Suspended Solid (TSS) and Turbidity at Chomor River, Kenyir Lake, Terengganu

4. CONCLUSION

Based on the appropriate spatial interpolation scheme, water quality maps were developed and used to examine the spatial and temporal variations. The result applied to investigate the level of temperature, TSS and TUR with inadequate spatial and temporal distribution at lake area. This investigation considering the temporal correlation between water quality parameters through the spatial interpolation on the quality of predictions is recommended. This study demonstrates the successful application of interpolation techniques to analyze spatial temporal variation of lakes water contamination. Normally, the interpolation method use more than two sampling station to triggered more accurate prediction. The increasing number of sampling location, the construction of interpolation prediction becomes more precise result. However, this study is one of trial prediction and to analyze the effectiveness of interpolation method using only two sampling location. This shows a great potential to increase the understanding of water quality variation in complex aquatic systems. Results of such research can assist in the implementation of adaptive management and restoration projects in large lakes by providing new insights and information to manage the ecotourism development at Kenyir Lake.

5. ACKNOWLEDGEMENTS

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