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Potential of field turbidity measurements for computation of total suspended solid in Tasik Kenyir, Terengganu, Malaysia

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ABSTRACT

The urbanization has significant effects on watershed hydrology and the quality of water in this catchment. One component of water quality is total suspended solids (TSS) which a significant part of physical and degradation and a good indicator of other pollutants on the surface of sediment in suspension. The purpose of this study is to investigate whether turbidity could produce a satisfactory estimate of TSS in urbanizing at the Tasik Kenyir. TSS and Turbidity were analyzed based on in-situ and ex-situ analyses were carried out according to the correlation matrix and linear regression methods at 14 (10–140 m) different depths for two sampling locations in the Tasik Kenyir (which are Chomor River and Mahadir Island- the name of sampling location in Tasik Kenyir), using data compiled. A log-linear model showed a strong positive correlation between TSS and Turbidity with is (R^2 = 0.991 for Chomor River and R^2 = 0.995 for Mahadir Island) with a regression equation of ln (TSS) = 1.32 ln (NTU) + C, with C not significantly different. From the result, water quality parameter (TSS and Turbidity) showed outlet significantly which decreased over depth caused the water quality deterioration of Tasik Kenyir development. These results strongly suggest that turbidity is a suitable monitoring parameter where water-quality conditions must be evaluated.

Keywords: Urbanization; Total suspended solid; Tasik Kenyir; Turbidity

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1. Introduction

Tasik Kenyir urbanization can have significant effects on watershed hydrology, water quality, and riparian functions. Decreasing level in water quality is reflected in increasing of particulate matter in the lake. The composition and total concentration of particulate matter in the aquatic environment is affected by the source and pathway of sediment input around the river basin stream habitat degradation [1]. These urbanization activities can potentially affect the production of total suspended solids (TSS) to the lake environment. The geomorphology, anthropogenic and hydrological factors also influence the water quality of the lake system [2,3]. The water quality as well as long terms changes in environment and sensitivity to other various factors that affect the environment. TSS is predominantly measuring the dry weight of sediment from a known volume of as subsample of the original. TSS is described as the concentration of solid-phase material suspended in a water-sediment mixture which usually expressed in milligrams per liter (mg/L) [4,5].

The turbidity parameter is widely used to represent these water quality indicators by establishing mathematical models on pollutant concentration and turbidity values. There are reliable quantitative relationship TSS concentration and turbidity. This study aimed to evaluate whether turbidity could produce a satisfactory estimate of TSS and little work has been done to assess the accuracy of correlating TSS to turbidity in lake urbanizing of the Tasik Kenyir, Terengganu. National water quality standard for Malaysia is a one of tool to evaluate the water quality of the Tasik Kenyir included the possible sources from anthropogenic activities which influenced the water quality were also given, many researchers have used the water quality index which involves the classification of rivers or river segments into classes of quality [6–11].

The rate of water quality contributing to environmental quality, this study was conducted in Lake Kenyir (or Tasik Kenyir for a local name) which one of the ecotourism areas in Peninsular Malaysia and the largest man-made lake in South East Asia with a surface area of about 36,900 ha and it is artificial well known as a lake surrounded by tropical forest. It lies at latitude 4° 41′ north and longitude 102° 40′ east and receiving water inputs from main rivers, the Terengganu River basin [12].

The lake covers 260 km² and contains 340 small islands, more than 14 waterfalls and as well as numerous rapids and rivers. Tasik Kenyir is one of the reservoirs in Malaysia that need serious attention in its management and conservation of its water quality resources. The lake has an average depth of 37 m with a maximum depth of 145 m. Its beautiful landscape and the surrounding natural environment provide a pleasant recreational retreat for urban residents. There are two stations were selected in Tasik Kenyir, which are Chomor River and Mahadir Island. The location for both points are N 05°00′ 59.9″, E 102°51′ 14.3″ for Chomor River and Mahadir Island is N 04°58′ 52.8″, E 102°43′ 58.5″ (Fig. 1). The locations of the sampling stations were chosen based on the land-use pattern or level urbanization of the area of Tasik Kenyir.

2. Materials and method

All the sample preparation and preservations conducted were following on the standard procedures provided by the United States Environmental Protection Agency methods. Turbidities were all monitored and measured in situ using a HACH 2100Q portable turbidimeter and the turbidity unit reported in nephelometric turbidity units (NTU) which is a measurement of the intensity of light being scattered when light is transmitted through a water sample. (Hach Company, P.O. Box: 389, Loveland, Colorado, 80539-0389, United States).

Three replicate water samples for each sampling station taken from across the lake and three turbidity readings were recorded. The average value of these nine turbidity measurements was used in this study. Then, the gravimetric method was used to analyze the TSS which measures in mg/L. TSS concentration was measured in the laboratory by filtering 250 mL water samples through a membrane with a 0.45 μm pore dried to a constant weight. The filter (filtration apparatus, Nalgene, U.S.A.) and retained sediment were also dried to a constant weight at the same temperature, and the

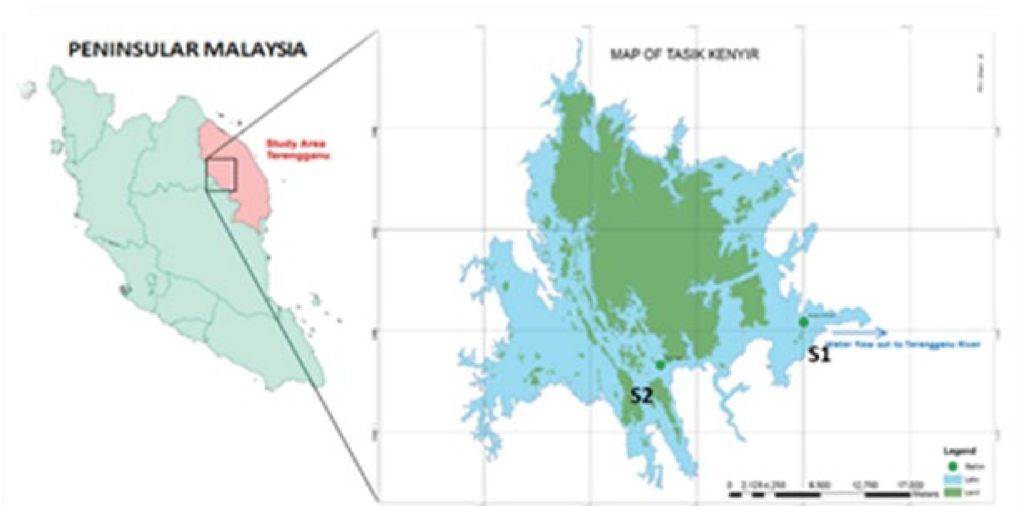


Fig. 1. Location of the sampling stations at Tasik Kenyir, Terengganu, Malaysia.

TSS value was calculated according to the added weight of the membrane. The 250 ml lake 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. An average value of three parallel subsamples was then used to provide the TSS concentration for each sample. TSS is measured by mg/L unit based on Eq. (1). Precisely precaution steps should be taken when the river water sample was taken because the interference of the river water flow should be minimum to avoid deposition of the measured suspended sediment [13,14].

$$\begin{aligned} TSS &= \{(WBF + DR) - WBF\} \text{ (mg)} \times 1{,}000 / VFW \text{ (mL)} \\ &= \text{mg/L}/1{,}000/1{,}000/1{,}000 \\ &= \text{tonne/L} \end{aligned} \quad (1)$$

where WBF = Weight of membrane filter; DR = Dry residue; VFW = Volume of filtered water (Sources: Kamarudin et al. [19]).

3. Result and discussion

The result of the TSS and turbidity for 10 m until 140 m surface samples from Tasik Kenyir (Chomor River and Mahadir Island) are shown in Figs. 2 and 3. Further understanding of the difference in TSS and Turbidity relationships between streams (depth of lake) other water bodies would require a more detailed study. From the hydrology theory proved the depth of lake decreasing due to the sediment production from the erosion process and the bottom composition of a mixture of inorganic sediment and rich organic matter washed in from the highly productive drainage areas [15]. TSS is a specific measurement of all suspended solids, organic and inorganic, by mass and TSS is the direct measurement of the total solids present in a water body. As such, TSS can be used to calculate sedimentation rates, while turbidity cannot. The range distribution TSS and turbidity respectively 24.44 ± 22.06 mg/L (Chomor River) and 11.658 ± 24.925 mg/L (Mahadir Island), 2.36 ± 13.36 NTU (Chomor River) and 2.33 ± 23.70 NTU (Mahadir Island). Mahadir Island compares to Chomor River.

There is a positive correlation between the deeper lake depth with TSS and turbidity at Mahadir River but there is a negative correlation between deeper lake depths with TSS at Chomor River, the value of TSS decreases when the deeper of depth with slightly decrease rate. This relationship proved by the quantity of R or the linear correlation coefficient which measured the strength and the direction of a linear relationship between two variables. The value of R of lake depth to turbidity and TSS are ranges between $-1 \leq R \leq +1$. The positive and negative signs used for positive

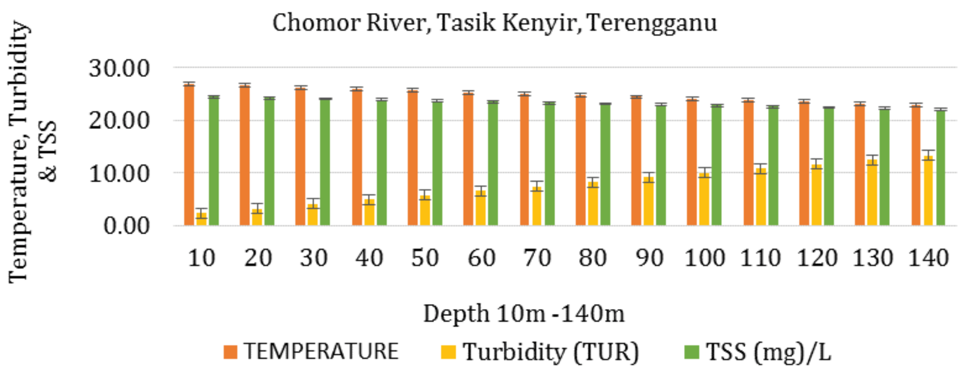


Fig. 2. Distribution of temperature (°C), turbidity/TUR (NTU) and TSS (mg/L) based on the depth at Chomor River, Tasik Kenyir, Terengganu.

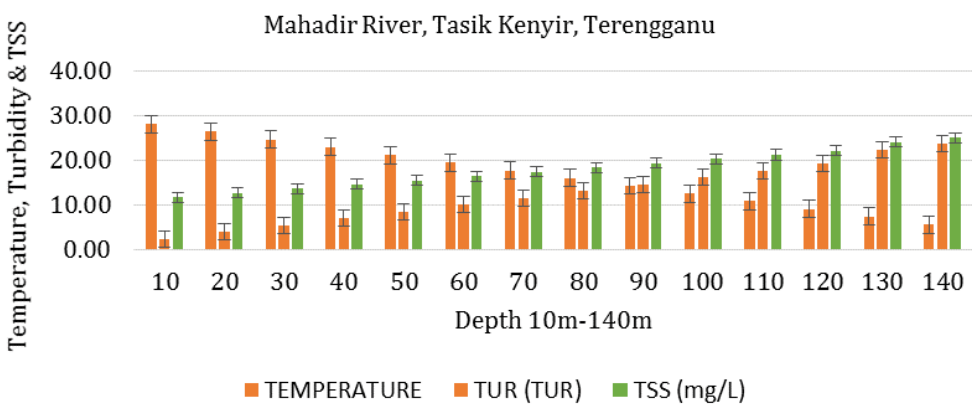


Fig. 3. Distribution of temperature (°C), turbidity/TUR (NTU) and TSS (mg/L) based on the depth at Mahadir Island, Tasik Kenyir, Terengganu.

linear correlations and negative linear correlations, respectively [16].

Chomor River situated nearby the dam area of Tasik Kenyir, the higher velocity of surface lake water compared to the bed area affected by the strong reaction flow of water from the dam. Meanwhile, Mahadir River was located to the settlements of the indigenous people at the Tasik Kenyir and more subject to contamination by organic substances on the water surface was detected from the values of TSS, there is a 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. The minimum and maximum value of Turbidity at Chomor River and Mahadir Island, 2.36 NTU and 2.33 NTU, 13.36 NTU and 22.18 NTU respectively. There is a larger gap between minimum and maximum value of Turbidity at Mahadir Island compared to Chomor River.

Figs. 4–6 shows the regression of turbidity with TSS in this study. The simple linear regression model is verified and findings reasonable estimates generated from the Tasik Kenyir prediction of water quality on TSS production and turbidity level. These predictions of the water quality parameters using the developed models are in good agreement with observed values. There are a low correlation of TSS and depth which $R^2 = 0.131$ and $R^2 = 0.001$ respectively. The production of TSS not only depends on the depth but also depends on the other geomorphology, hydrological and anthropogenic factors [17,18].

Besides that, the study proved the correlation between Turbidity and depth at Chomor River ($R^2 = 0.9514$) more significantly compared to Mahadir Island ($R^2 = 0.794$). One factor triggered the value of turbidity more contributed at downstream and middle stream compared upstream areas, other factors also including such as the dumping

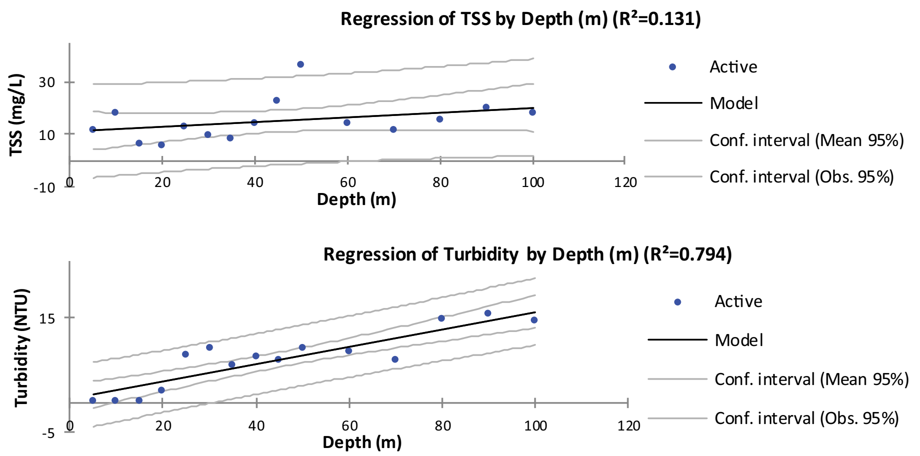


Fig. 4. Regression of depth with TSS and turbidity at Chomor Island, Tasik Kenyir, Terengganu.

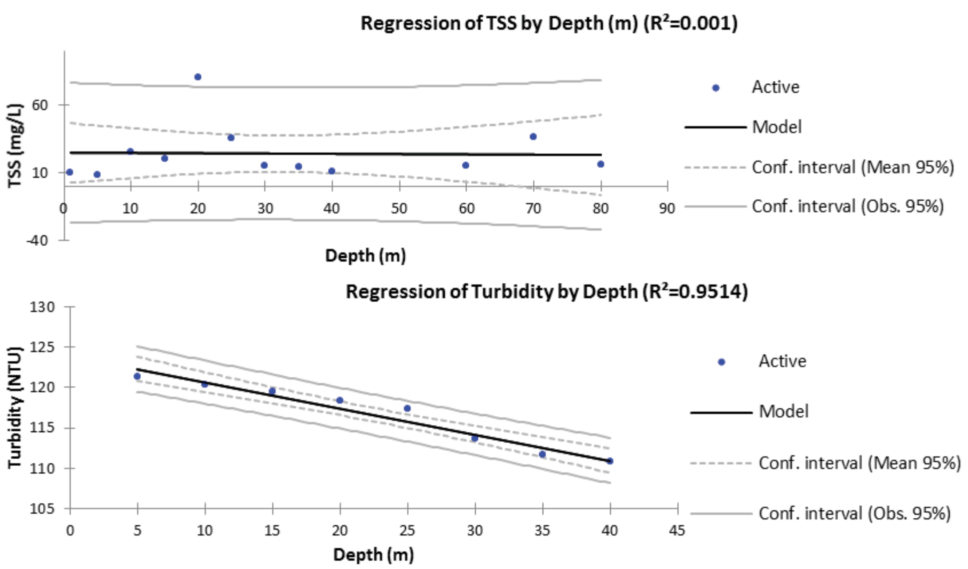
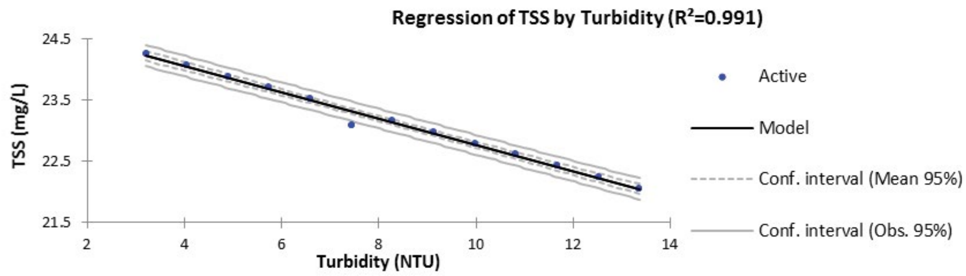


Fig. 5. Regression of depth with TSS and turbidity at Mahadir Island, Tasik Kenyir, Terengganu.



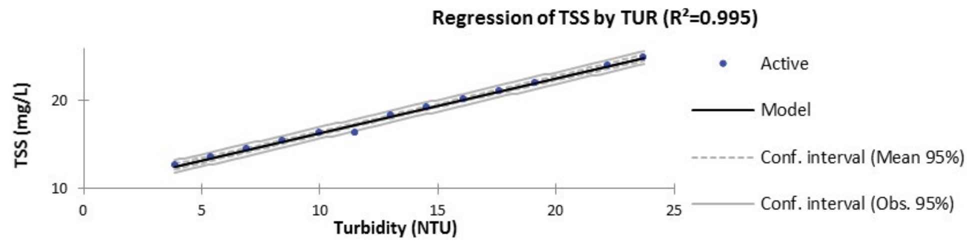


Fig. 6. Regression of turbidity with TSS at Chomor River and Mahadir River, Tasik Kenyir, Terengganu.

garbage and waste domestic from domestic activities and development and which ultimately contaminated the Tasik Kenyir. The TSS in Tasik Kenyir more useful and representative characterization of deeper conditions can be made within the ordinary constraint of time and budget and the inescapable variability of water-quality parameters. The model shows a strong positive, log-linear relationship between turbidity and TSS with a correlation coefficient of $R^2 = 0.991$ (Chomor River) and $R^2 = 0.995$ (Mahadir River). The correlation between TSS and turbidity more efficient in predicting of TSS concentration in a lake or river. The measurement of turbidity is possibly the most economic chosen for estimating total suspended solid concentration in a lake or river [19–24].

4. Conclusion

The result applied to investigate the level of TSS and turbidity with inadequate spatial and temporal distribution at the Tasik Kenyir area. This study considering the temporal correlation between water quality parameters through the statistical analysis on the quality of predictions is recommended. From the analysis, the potential of field turbidity measurements for computation of TSS and turbidity, the researcher assisted in the implementation of adaptive management and restoration projects in large lakes by providing new insights and information to manage the ecotourism development at Tasik Kenyir.

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