Water Quality of Batang Merao Watershed and Implementation of Landsat 8 OLI/TIRS for the Transparency of Lake Kerinci Waters

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Abstract. This research aims to analyze the water quality of the Batang Merao watershed and the algorithm model implementation from Landsat 8 OLI/TIRS for the transparency of Lake Kerinci waters. The method used is descriptive quantitative which is used to obtain measured data on water quality using the IP method based on KEPMENLH No. 115/2003 and PP No. 82/2001, and the kriging method from an algorithm of the Landsat 8 OLI/TIRS for TSS concentrations with the transparency of the waters of Lake Kerinci. Based on the test results of water samples in the Batang Merao DAS showed that several water quality parameters exceeded the class II water quality standard PP No. 82/2001 covers DO, BOD, and oil & fats parameters. Relationship between TSS concentration and water transparency of Kerinci Lake has a high coefficient of determination reaching 0.8344, this indicates the transparency of Kerinci Lake is around 2 m or less. This means that the waters of Lake Kerinci have lower transparency.

Keywords: Water Quality, Watershed, Transparency, Landsat, Lake Kerinci..

1 Introduction

Lake Kerinci was formed from a tectonic fault process in the Bukit Barisan pathway which is one of the areas that has great potential (Poedjopradjitno, 2012; de Maisonneuve et al., 2019; Hermon et al., 2021), but its sustainability is being threatened by sedimentation and eutrophication processes originating from the catchment area. The Lake Kerinci catchment area has a very fertile soil type and is sensitive to erosion, so it is easily eroded by rainfall and then carried by the river flow into the lake. The high water sloping and very intensive land management but not yet implementing a conservative farming system, have triggered a high rate of sedimentation that enters the lake. This is also influenced by the existence of 10 rivers which are the inlets for the water supply at Lake Kerinci.

The potential for water supply for Lake Kerinci which is quite guaranteed throughout the season is related to the existence of the Kerinci Seblat National Park (TNKS) which is a conservation region of protected forest with an area of nearly 1.5 million ha (MacKinnon et al., 2019). de Maisonneuve et al (2019) add, this lake has an area

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of 46 km², with an average lake depth of 97 m, a water volume of 1.6 million m³, and is located at an altitude of 787 m above sea level.

The river system that flows into the Kerinci Lake region can be classified into two (2) groups, namely: 1) The river system which is the source of inlet water for Lake Kerinci, namely the Batang Merao watershed which is part of the Kerinci lake catchment area, Kerinci river, Tebing Tinggi river, Siulak or Merau river, Kapur river, and Jujun river; and 2) The river system which is the source of the lake's outlet water, namely the Merangin watershed which is part of the Batanghari sub-watershed. The Merangin River is a river that comes out of Lake Kerinci, and its water resources are utilized for the Regional Drinking Water Company (PDAM) and the Merangin Hydroelectric Power Plant (PLTA). Where the upstream of the Batang Merao watershed is in the highlands of the Kerinci volcano, which cross Sungai Penuh City, and empties into Lake Kerinci. Research by Firdaus & Nakagoshi (2013) explains the management of the Batang Merao watershed has faced various problems, including the large number of sand or stone mining activities in upstream and land use change from agricultural land becoming settlement land. In addition, some people activities utilize the riverbank areas for livestock activities. Putra et al (2024) add sand mining activities can result in changes in land use to open land and cause high levels of erosion.

In addition, Putra et al (2017) also added that water utilization activities in the upstream area will have an impact on the downstream watershed in the form of changes in water storage and control of water release in the downstream area, in the form of changes in water quantity and water quality. The existence of people activities that throw waste into rivers and run-off from rice field activities and the presence of illegal mining causes water quality to exceed river water quality standards. The limited availability of clean water has been felt by the people in several river areas of the Batang Merao watershed, such as in Koto Dumo Village, Rawang Sub-district. The people use polluted Batang Merao river water to meet their daily water needs such as bathing, washing, and toilets.

According to the report results of the Environmental Performance Information Document (DIKPLHD) Sungai Penuh City 2018 in Putra et al (2019); Ningsih et al (2020); Hermon et al (2021) show there has been a decrease in water quality with an increase in the value of the IP of the Batang Merao watershed, namely 0.86 (not polluted) in 2014 to 1.49 (lightly) in 2017. Based on these problems, the researchers determined indicators of monitoring the pollution load of water quality in the Batang Merao watershed and Lake Kerinci which had an impact on environmental sustainability. Given the problem in the Lake Kerinci area are quite complex and there are still few studies, it is necessary to carry out an analysis so that the catchment area and river in the Batang Merao watershed can be utilized according to their designation and the people's water needs can be fulfilled and sustainable. This research aims to analyze the water quality of the Batang Merao watershed and the algorithm model implementation from Landsat 8 OLI/TIRS for the transparency of Lake Kerinci waters.

2 Methods

This research was conducted in the Batang Merao watershed, which is located in Kerinci Regency and Sungai Penuh City-Jambi Province (Fig 1). The area of the Batang Merao watershed is 679692.21 ha with the main river being the Batang Merao with a length of ± 53.63 km. The research was conducted in June 2022 and an analysis related to water quality in the Kerinci lake region was carried out based on data on water brightness and Total Suspended Solid (TSS).

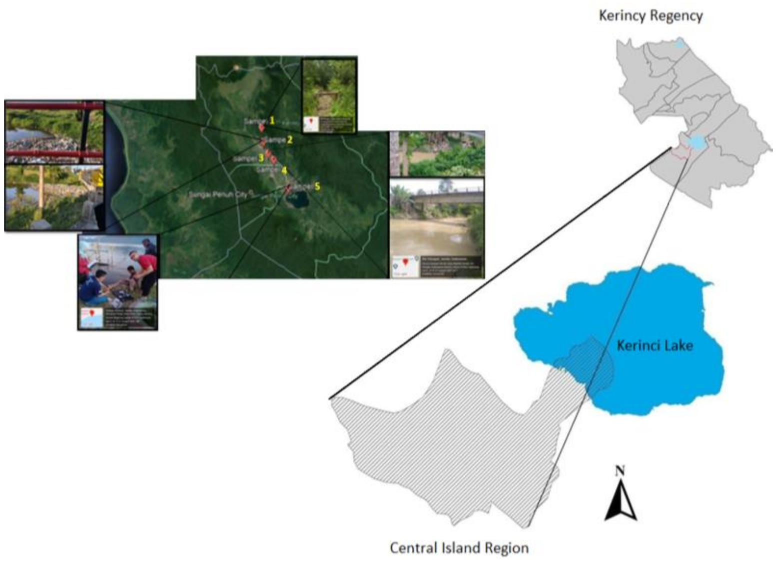

Fig.1. Field survey location map in research

A quantitative descriptive method (Keeler et al., 2012) was used to obtain measurable data from monitoring river water quality in Batang Merao watershed and descriptive methods to determine the water quality of Lake Kerinci using the kriging method from an algorithm of the Landsat 8 OLI/TIRS for TSS concentrations with the transparency of the waters of Lake Kerinci with the data used in this research are primary data. Primary data were obtained from sampling data and results of water quality testing in the Batang Merao watershed are three (3) sample points and two (2) sample points in Lake Kerinci waters (Fig 1), while the analysis uses a reliable discharge approach (Q80) (Purnaditya & Asyiah, 2021).
Sampling points were determined by the sample survey method, namely dividing the research area into several parts that were considered to represent the research area. Sampling points are determined based on the characteristics and forms of utilization of water resources and people activities around the watershed. Water quality sampling was carried out using the grab sample method and duplicate samples were taken for a total of 5 samples. While the analysis of water quality data for water quality status is carried out using the Pollution Index (PI) method based on the Decree of the State Minister for the Environment (KEPMENLH) No. 115/2003 concerning "Guidelines

for Determining Water Quality Status" and Government Regulation (PP) No. 82/2001 concerning "Management of water quality and control of water pollution" (Melinda et al., 2021; Anggraini & Wardhani, 2021). This method is used to determine the level of pollution from pollutant sources on the quality of waters for a specific designation, both for the entire body of water or part of water (river).

The next step is a measurement of TSS concentrations using water samples taken from lake waters with different locations, and to water transparency using Secchi Disk Transparency (SDT) then all data is analyzed and correlated to obtain a correlation algorithm between TSS and lake water transparency. Measurements of TSS and water transparency were carried out in Lake Kerinci waters on 1-2 June 2022 to obtain TSS concentrations in a varying range of values (low to high TSS concentrations).

Reclassification of Landsat 8 OLI/TIRS for TSS was carried out to classify images of TSS concentrations to simplify the process of interpretation and calculations in classification. The application from the Van Hengel and Spitzer Algorithms is carried out by looking for matrix components from previously processed images, to obtain a depth index (Sukmono et al., 2022). To obtain absolute depth, modeling is carried out between the depth index as x and the depth of field as y. So that the best depth algorithm modeling is obtained, namely the polynomial regression model 3 with an R^2 value of 0.7127 and an RMS error of 1.2929. For more details, the bathymetry (depth) of Lake Kerinci is presented in Fig 2, which originates from the work of de Maisonneuve et al (2019) as follows.

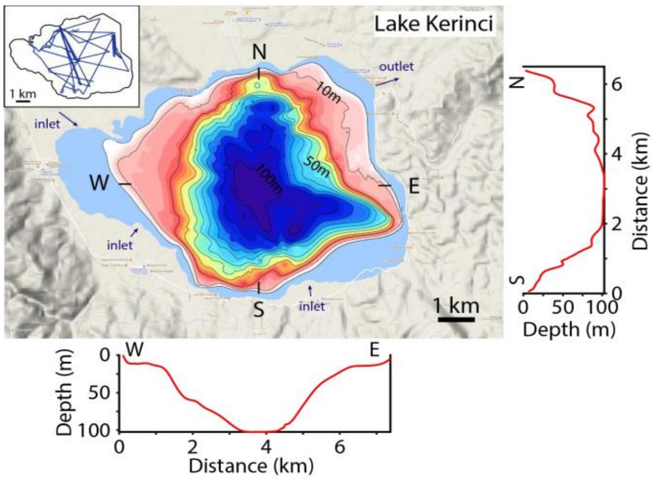

Fig. 2. Bathymetry (depth) map of Lake Kerinci (de Maisonneuve et al., 2019)

To know the level of truth of the algorithm results, spatial validation is carried out between field data and image data. Spatial analysis is carried out by calculating the difference between the field data and the image and then calculating the standard deviation. To calculate the deviation from the field data and image data as a whole, the field data is raster interpolated using the Kriging method (Dewata & Putra, 2021)..

3 Results

3.1 Water discharge, and surface run-off coefficient

Calculation of water availability begins with finding the minimum discharge. The minimum debit data for the last 3 months which have been obtained from the Secondary Data of the Environmental Office of Kerinci Regency, are then sorted from the largest to the smallest discharge data. Water availability is calculated using a water balance using the reliable debit formula (Q80) (Hidayat & Ferdina, 2019). Based on the results of the discharge calculation, the availability of river water in the Batang Merao watershed is 20.12 m^3/second (Fig 3). Maximum and minimum discharge fluctuations can be used as indicators of land use quality. The occurrence of discharge fluctuations affects the value of the River Regime Coefficient (RRC) (Rachman et al., 2021) which is a comparison between Q_{max} and Q_{min}.

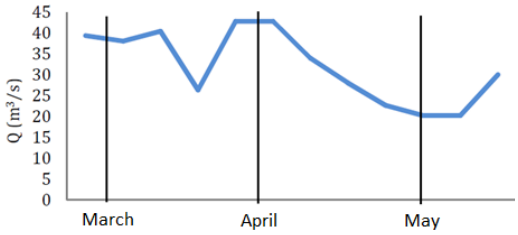

Fig. 3. River discharge in the Batang Merao watershed from March to May 2022

The land use Changes of the Batang Merao watershed are expected to have an impact on the run-off water coefficient and water quality of Lake Kerinci. The run-off coefficient increases when there is development of land cover and decreases as vegetation conservation improves. Utilization of land cover will lead to changes in land use with a tendency to be more watertight, causing puddles and thick surface water run-off, this can cause high water discharge and cause flooding. The results of calculating the surface run-off coefficient values in the Batang Merao watershed during the periods of 2018, 2019, and 2021 (Fig 4) with an algorithm using Landsat 8 OLI/TIRS 2020-2021, which represent catchments in the Kerinci Lake region show that the average value of the run-off coefficient has remained relatively unchanged, but for catchments in settlement areas and plantations, there is an increase in run-off value.

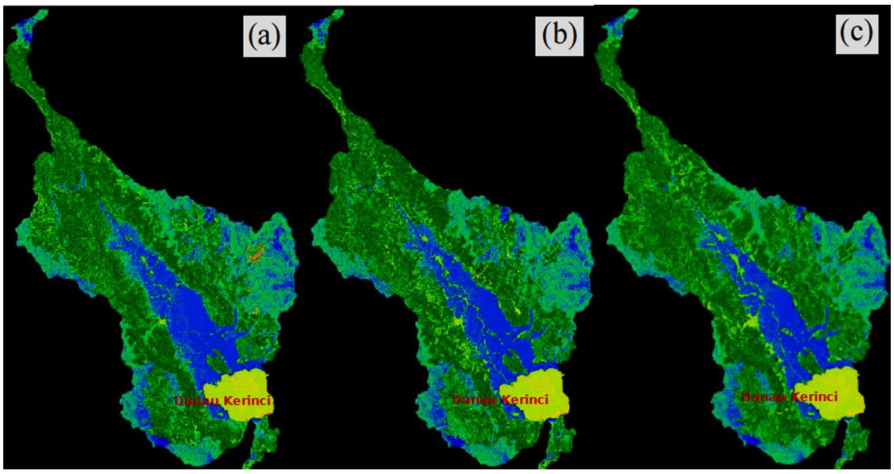

Fig.4. Changes in catchment run-off coefficient, a) 2018; b) 2019, and c) 2020

The results of calculating the average surface run-off coefficient during 2018, 2019, and 2021 periods are shown in Table 1, where the surface run-off coefficient has increased from 0.420 in 2018, to 0.427 in 2019, and 0.437 in 2021. An increase in the flow coefficient causes a decrease in water absorption into the ground, which eventually increases the amount of ground run-off. In the next stage, it causes an increase in water discharge and soil erosion in the catchment area.

Table 1. Coefficient of surface run-off of the Batang Merao watershed in 2018-2021

Year	2018	2019	2021
Average run-off coefficient	0,420	0,427	0,437

3.2 Water quality

To determine the water quality of the Batang Merao watershed was carried out using the Water Quality Test Kit Professional 8 in One EC-900 on samples taken from five (5) points originating from the Batang Merao watershed and Lake Kerinci. The Batang Merao watershed has not yet been assigned according to the river class. Based on Government Regulation (PP) No. 82/2001 (Arthana et al., 2021), if water quality standards at water sources have not been and are not set, then class II water quality criteria apply which can be used for water recreation infrastructure/facilities, cultivation of freshwater fish, animal husbandry, water for irrigating plantations and or other uses that require the same quality of water as that user. The results of testing the river quality of the Batang Merao watershed can be seen in Fig 5 and Table 2 below.

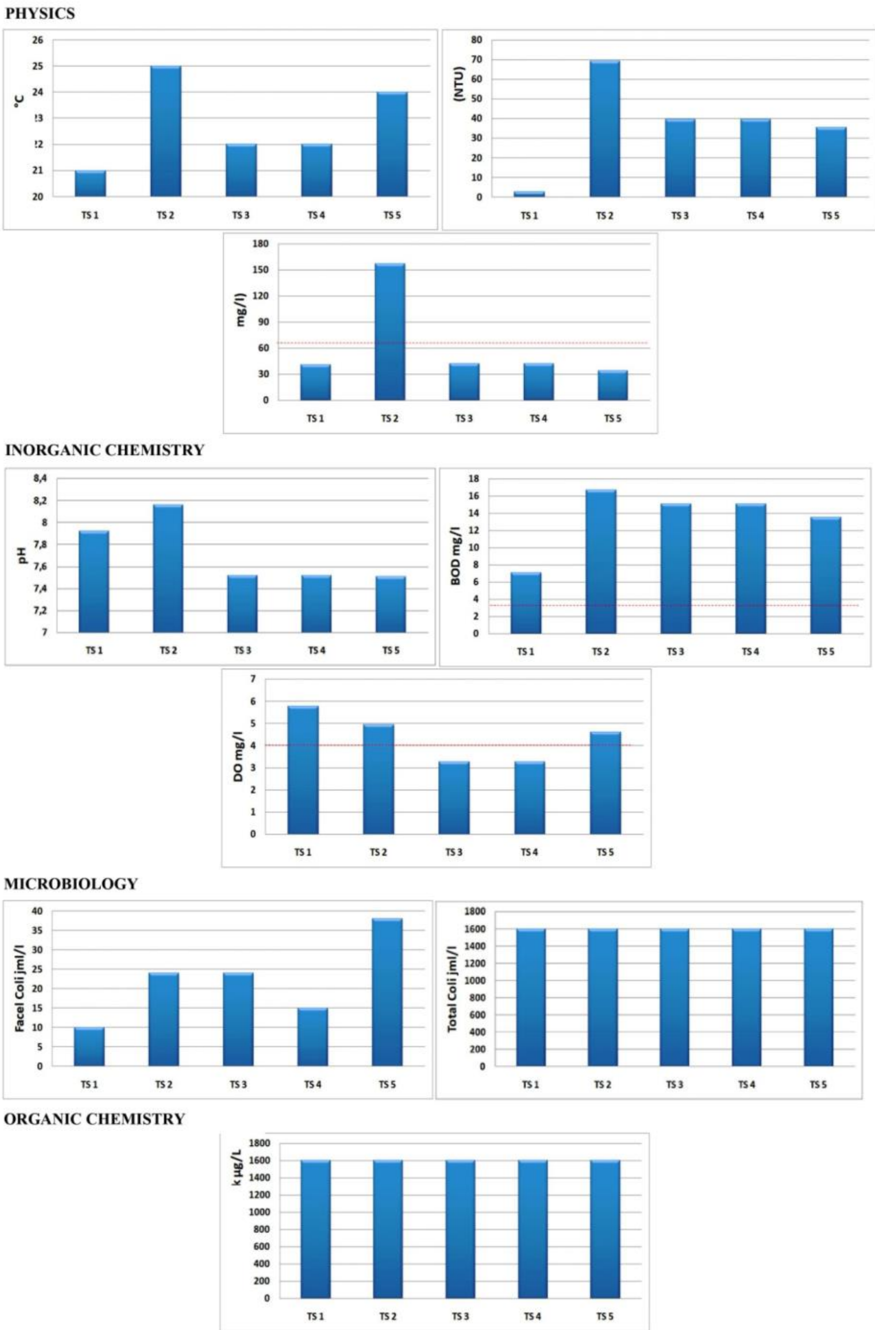

Fig. 5. Graph of water quality monitoring results for the Batang Merao watershed

Table 2. Results of testing the water quality of the Batang Merao watershed

Parameter	Water quality standard (class II)	Unit	Sampling point				
			1	2	3	4	5
PHYSICS							
Temperature	-	°C	21	25	22	22	24
Turbidity	-	NTU	2,76	69,3	39,7	39,7	35,6
TSS	50	mg/L	41	157	42	42	34
INORGANIC CHEMISTRY							
pH	6-9	-	7,92	8,16	7,52	7,52	7,51
BOD	3	mg/L	7,06	16,7	15,09	15,09	13,49
DO	4	mg/L	5,78	4,96	3,27	3,27	4,61
MICROBIOLOGY							
Fecal Coli	1000	Amount/100 mL	10	24	24	15	38
Total Coli	5000	Amount/100 mL	>1600	>1600	>1600	>1600	>1600
ORGANIC CHEMISTRY							
Oils & Fats	1000	µg/L	2400	1200	5600	2500	8100

The results of testing samples of river water in the Batang Merao watershed showed that several water quality parameters exceeded the class II water quality standard PP No. 82/2001 covers DO, BOD, and oil & grease parameters. The results of the TSS parameter water quality analysis showed a significant increase in concentration from sampling point 1 of 41 mg/l to 157 mg/l at point 2,42 mg/l at points 3-4, and 34 at point 5. Based on PP 82/2001 Class II of 50 mg/l, the water quality conditions of the Batang Merao watershed when viewed from the TSS parameter sample 2 exceeds the water quality standard value. A significant increase in TSS concentration occurred at location 2 which was influenced by sand and rock mining activities around the sampling location. The high concentration of TSS at that location was caused by the addition of particulates in the form of silt and fine sand, the residue from washing sand that was wasted into the river. Ghosh et al (2023) explain, the more volume of sand taken will increase the concentration of TSS and the more turbid the water will be. Mining activities can increase the rate of erosion and adversely affect fisheries.

The results of testing the BOD concentration in the Batang Merao watershed showed values ranging from 7.06-16.7 mg/l as shown in Fig 5. BOD concentrations at all points did not meet the class II water quality standard value of 3 mg/l. The high concentration of BOD in the research area indicates that there are people activities around the watershed that still use the Batang Merao watershed as a final disposal site for household domestic liquid waste, a place for bathing and washing. In some areas, latrines are still found along the Batang Merao watershed and sewage from household activities is directly discharged into the water bodies. In addition, the high concentration of BOD at several points is also influenced by the sampling factor which is carried out during the dry season so that the available river water discharge is very small but the pollution load from domestic waste that enters water bodies is quite large.

The highest concentration of BOD was at sampling point 2 which was 16.7 mg/l, while the lowest concentration was at sampling point 1 of 7.06 mg/l. The high concentration of BOD is also influenced by the presence of sewerage channels for household liquid waste that is discharged directly into water bodies without prior treatment and the people still uses the river as a place for toilets and garbage disposal. Bai et al (2022) add, water conditions that accommodate waste from settlements and/or industrial waste without treatment often exceed 200 mg/l. Determining the water quality status of the Batang Merao watershed uses the IP method (Nurrohman et al., 2019; Suriadikusumah et al., 2021; Putra et al., 2022). Water quality parameters compared with class I, II, III, and IV water quality standards PP No. 82/2001 (Ajiwibowo et al., 2019; Dewata, 2019). Water quality status is determined by the IP method following KEPMENLH No. 115/2003 concerning "Water Quality Status". In determining the status of water quality, the parameters used in calculating the pollution index are TSS, pH, BOD, DO, Fecal Coli, Total Coli, Oil & grease. The results of calculating the pollution index at each sampling point can be seen in Table 3 below.

Table 3. Pollution Index (IP) of the Batang Merao watershed

Sampel	PI in each class of water							
	Class I		Class II		Class III		Class IV	
	value	Criteria	value	Criteria	value	Criteria	value	Criteria
TS 1	3.03	Lightly	2.41	Lightly	2.09	Lightly	0.44	Meet standards
TS 2	7.25	Medium	6.65	Medium	5.53	Medium	1.25	Lightly
TS 3	3.95	Lightly	3.45	Lightly	3.4	Lightly	1.07	Lightly
TS 4	4.26	Lightly	3.64	Lightly	2.54	Lightly	1.38	Lightly
TS 5	7.8	Medium	7.2	Medium	6.12	Medium	0.9	Meet standards

3.1 Modeling the water quality distribution of Kerinci Lake

Relationship between TSS concentration and water transparency is an exponential model (Wirabumi et al., 2021), and has a high coefficient of determination reaching 0.8344. The developed water transparency algorithm is applied to Landsat 8 OLI/TIRS data to obtain the distribution of water transparency in Lake Kerinci waters. Fig 6 shows a model of TSS distribution and water transparency in Lake Kerinci using Landsat 8 OLI/TIRS. Lake Kerinci waters have low concentrations of TSS in the middle of the lake region, and high concentrations of TSS along the lake borders.

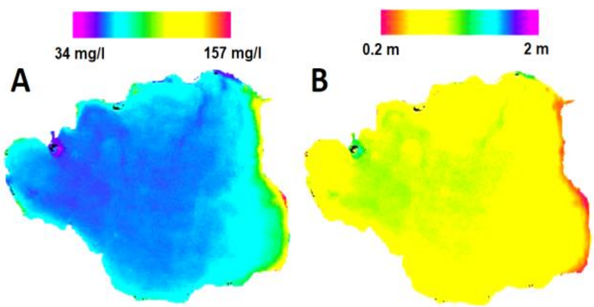

Fig. 6. Model of TSS distribution and water transparency in Lake Kerinci

The highest TSS concentrations along the lake boundary are believed to be due to soil erosion in watersheds that are carried from rivers to the lake water and soil erosion that occurs along the lake region. As mentioned in the previous discussion, there is an inverse correlation between water transparency and TSS concentration in Lake Kerinci. Wahyono (2012) states that, in general, most of the water in Lake Kerinci is less than 2 m clear, although the water transparency is greater than 2 m in the central part of the lake. There are several sand pits around Lake Kerinci due to sand mining around Lake Kerinci. The presence of sand mining areas is thought to increase water turbidity and reduce the water transparency of Lake Kerinci.

All sampling data for the Kerinci Lake waters show an inverse relationship between TSS and water transparency. TSS concentration increases with decreasing water transparency, while water transparency has different values for each TSS concentration value. The TSS concentration values ranged from 34 to 157 mg/l, the water transparency ranged from 0.2 m to 2 m, and based on the measured data, the water in Lake Kerinci is known to have low water transparency. increase. The measured data are then recalculated using the Kriging method in an ArcGIS application (Dewata & Putra, 2021) to obtain the mean and variance of water transparency at each TSS concentration value. The results are shown again in Figure 6 and show that water transparency is inversely proportional to TSS concentration. A study by Ballantine et al (2014); Hannouche et al (2017); Hermon et al (2022) stated that TSS is linearly correlated with turbidity and that TSS and turbidity are inversely related to water transparency. Therefore, the correlation between his TSS and water transparency found in this study yields the same results as in previous publications.

4 Conclusions

Based on the analysis of river discharge data from the Batang Merao watershed in March-May 2022, water availability in the Batang Merao watershed is 20.12 m³/second covering domestic, non-domestic, agricultural, animal husbandry, and fisheries needs. Where the availability of water in the Batang Merao watershed has not been able to meet the total water needs of the people in the Batang Merao watershed with a water deficit of 4.01 m³/second. Based on the IP value, the water quality status of the Batang Merao watershed is in a lightly polluted condition caused by pollution from domestic sewage, livestock waste, mining activities (sand and rock mining), and agricultural run-off. The algorithm developed in this study has a high coefficient of determination, reaching 0.834. The implementation of the algorithm for Landsat 8 OLI/TIRS shows that the water transparency in Lake Kerinci is around 2 m or less. This means that the waters of Lake Kerinci have lower water transparency.

References

[1] Ajiwibowo, H., Ash-Shiddiq, R.H.B., & Pratama, M.B. (2019). Water Quality and Sedimentation Modeling in Singkarak Lake, Western Sumatra. *International Journal of GEOMATE, 16*(54), 94-102

[2] Anggraini, Y., & Wardhani, E. (2021). Studi Mutu Air Sungai Cibaligo Kota Cimahi Provinsi Jawa Barat dengan Metode Indeks Pencemar. *Jurnal Serambi Engineering*, *6*(1).478-1487

[3] Arthana, W., Adnyana, W. S., Suyasa, W. B., & Sudipa, N. (2021). Analysis of Water Quality in Batujai Reservoir Due to Community and Business Activities in Central Lombok Regency. *Journal of Environmental Management & Tourism*, *12*(1), 30-42

[4] Bai, B., Bai, F., Li, X., Nie, Q., Jia, X., & Wu, H. (2022). The remediation efficiency of heavy metal pollutants in water by industrial red mud particle waste. *Environmental Technology & Innovation*, *28*, 102944

[5] Ballantine, D. J., & Davies-Colley, R. J. (2014). Water quality trends in New Zealand rivers: 1989–2009. *Environmental Monitoring and Assessment*, *186*, 1939-1950

[6] Dewata, I. (2019). Water quality assessment of rivers in Padang using water pollution index and NSF-WQI method. *International Journal of GEOMATE*, *17*, 192-200

[7] Dewata, I., & Putra, A. (2021). Kriging-GIS model for the spatial distribution of seawater heavy metals. *Periodicals of Engineering and Natural Sciences*, *9*(2), 629-637

[8] de Maisonneuve, C.B., Eisele, S., Forni, F., Hamdi., Park, E., Phua, M., & Putra, R. (2019). Bathymetric survey of lakes Maninjau and Diatas (West Sumatra), and lake Kerinci (Jambi). *Journal of Physics: Conference Series. 1185*(1), 012001.

[9] Firdaus, R., & Nakagoshi, N. (2013). Dynamic Patterns and Socioeconomic Driving forces of land use and land cover change in Humid Tropical Watersheds: A Case Study of Batang Merao watershed, Indonesia. *International Research Journal of Environmental sciences*, *2*(12), 89, 96

[10] Ghosh, S., Saha, S., & Bera, B. (2023). Dynamics of total suspended solid concentrations in the lower Raidak river (Himalayan foreland Basin), India. *Advances in Space Research*, *71*(6), 2846-2861

[11] Hannouche, A., Joannis, C., & Chebbo, G. (2017). Assessment of total suspended solids (TSS) event load and its uncertainties in combined sewer system from continuous turbidity measurements. *Urban Water Journal*, *14*(8), 789-796

[12] Hidayat, A., & Ferdina, D. (2019). Planning Optimization Planning Irigation Area of Solok Sumatera West Regency. *Journal of Applied Science, Engineering, Technology, and Education*, *1*(2), 167-182

[13] Hermon, D., Dewata, I., Putra, A., Driptufany, D.M., & Fajrin. *Seri 1 Manajemen Risiko Bencana Kawasan Danau WATERSHED DANAU KERINCI (Kerusakan Lahan, Valuasi Ekonomi, dan Keberlanjutan)*. CV Amerta Media

[14] Hermon, D., Gusman, M., Putra, A., & Dewata, I. (2022). Value estimating of the sedimentation rate at the shipwreck sites (MV Boelongan Nederland) the Mandeh Bay Region-Pesisir Selatan Regency. *IOP Conference Series: Earth and Environmental Science*. 967(1), 012007

[15] Keeler, B.L., Polasky, S., Brauman, K.A., Johnson, K.A., Finlay, J.C., O'Neill, A., Kovacs, K., & Dalzell, B. (2012). Linking water quality and well-being for improved assessment and valuation of ecosystem services. *Proceedings of the National Academy of Sciences*, *109*(45), 18619-18624

[16] MacKinnon, K., van Ham, C., Reilly, K., & Hopkins, J. (2019). Nature-based solutions and protected areas to improve urban biodiversity and health. *Biodiversity and health in the face of climate change*, 363-380

[17] Melinda, T., Sholehah, H., & Abdullah, T. (2021). Penentuan Status Mutu Air Danau Air Asin Gili Meno menggunakan Metode Indeks Pencemaran. *Jurnal sanitasi dan lingkungan*, *2*(2), 199-208

[18] Ningsih, S. R., Ekaputra, E.G., & Goembira, F. (2020). Analisis Ketersediaan, Kebutuhan dan Kualitas Air Pada DAS Batang Merao. *Jurnal Ilmu Lingkungan*, *18*(3), 545-555

[19] Nurrohman, A. W., Widyastuti, M., & Suprayogi, S. (2019). Evaluation of Water Quality Using Pollution Index in Cimanuk Watershed, Indonesia. *Ecotrophic, 13*(1), 74-84
[20] Poedjopradjitno, S. (2012). Morfotektonik dan Potensi Bencana Alam di Lembah Kerinci Sumatera Barat, Berdasarkan Analisis Potret Udara. *Jurnal Geologi dan Sumberdaya Mineral*, *22*(2), 101-113
[21] Purnaditya, N. P., & Asyiah, S. (2021). Quantifying the Reliable Discharges as an Incipient Analysis of Agricultural Planning and Developing in Ciujung Watershed. *IOP Conference Series: Earth and Environmental Science*. *715*(1), 012004.
[22] Putra, A., Wisha, U. J., & Kusumah, G. (2017). Spatial analysis of the river line and land cover changes in the Kampar River Estuary: the influence of the Bono Tidal Bore Phenomenon. *Forum Geografi*. *31*(2), 220-231
[23] Putra, R. A., Wardhani, E., & Halomoan, N. (2019). Perencanaan Sistem Penyaluran Drainase Di Kecamatan Hamparan Rawang, Kota Sungai Penuh. *ENVIROSAN: Jurnal Teknik Lingkungan*, *2*(2), 87-92
[24] Putra, R. S. P., de Rozari, P., & Soetedjo, P. (2022). Water Pollution Study and its Control Strategies in the Boentuka Sub-watershed, South Timor Regency, Timur Nusa Tenggara Province. *Journal of Humanities and Social Sciences Studies*, *4*(1), 21-41
[25] Putra, A., Hermon, D., Dewata, I., Barlian, E., Triyatno., & Elbeltagi, A. (2024). The Universal Soil Loss Equation (USLE) Method for Erosion Prediction and Conservation Measures at the Air Dingin Watershed of the Upstream Part in Padang City, Indonesia. In: *Erosion Measurement, Modeling, and Management Challenges and Solutions*, CRC Press
[26] Rachman, L. M., Nursari, E., & Baskoro, D. P. T. (2021). Application of SWAT in selecting soil and water conservation techniques for preparing management recommendation of Cilemer watershed, Banten, Indonesia. *IOP Conference Series: Earth and Environmental Science. 622*(1), 012023
[27] Sukmono, A., Aji, S., Amarrohman, F. J., Bashit, N., & Saputra, L. R. (2022). The Extraction of Near-Shore Bathymetry using Sentinel-2A Satellite Imagery: Algorithms and Their Modifications. *TEM Journal*, *11*(1), 150
[28] Suriadikusumah, A., Mulyani, O., Sudirja, R., Sofyan, E. T., Maulana, M. H. R., & Mulyono, A. (2021). Analysis of the water quality at Cipeusing river, Indonesia using the pollution index method. *Acta Ecologica Sinica*, *41*(3), 177-182
[29] Wahyono, A. (2012) Indentifikasi Sistem Penguasaan Sumberdaya Tradisional Guna Memahami Kearifan Lokal Masyarakat Sekitar Danau Kerinciindentifikasi Sistem Penguasaan Sumberdaya Tradisional Guna Memahami Kearifan Lokal Masyarakat Sekitar Danau Kerinci. Prosiding Seminar Nasional Limnologi VI 2012, 79-90
[30] Wirabumi, P., Kamal, M., & Wicaksono, P. (2021). Determining effective water depth for total suspended solids (TSS) mapping using Planet Scope imagery. *International Journal of Remote Sensing*, *42*(15), 5784-5810.