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Total Suspended Solid (TSS) Estimation in Lake Tempe, South Sulawesi Using Sentinel-2B Imagery

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***Abstract* - Lake Tempe is located in three districts, namely Wajo, Sidenreng Rapang, and Sopeng, South Sulawesi. The water quality in Lake Tempe needs to be considered both the quality and the quantity of the water. Total Suspended Solid (TSS) is one of the calculations and analysis of air quality. The large of TSS distribution can overcome the effects of sedimentation thereby reducing the need for lakes in saving water. TSS distribution at Lake Tempe can be accessed through Sentinel 2B imagery with acquisition time 10 April 2019 and spatial resolution of 10 meters. The algorithm used is NSMI (Normalized Suspended Material Index) algorithm then the results are compared with TSS measurements result in the field. The time of the study was conducted in April 2019 at Lake Tempe, South Sulawesi. The result from samples showed various TSS value which is in the range of 65 mg/L to 203 mg/L with R^2 of 0.1194 and standard deviation of 8.7106. High TSS value on the banks of the North lakes also had high sedimentation. Low TSS value are in the middle of the lake with small sedimentation and deeper lake.**

Keywords—Sentinel 2B, NSMI (Normalized Suspended Material Index) Algorithm, Lake Tempe, TSS.

I. Introduction

Water is a natural resource that can be utilized for the life of living things. Living things, especially humans, cannot release their dependence on water. Utilization of water resources should be done wisely so that their existence remains sustainable, both in terms of quantity or quality. Sources of water that can be used to meet the needs comes from rivers, groundwater and lakes/reservoirs. One source of water that is used by humans is Lake Tempe.

Lake is calm waters that flow in slow currents. Lake Tempe based on its formation is a lake of flood exposure originating from the depression of the Asia-Australia earth plate, located in the South Sulawesi region with coordinates 4°00'00" - 4°15'00" South Latitude and 119°52'30" - 120°07'30" East Longitude. The river leading to the lake consists of 23 rivers, which are included in Bila and Walanae watersheds [1]. Lake Tempe is one of 15 national priority lakes in Indonesia. The quality and quantity of water is a major concern. The physical quality of water must also be considered because it will affect the organisms that live in it. One of the parameters that can be used for calculation and analysis of water quality is Total Suspended Solid (TSS).

TSS is a solid material which includes organic and inorganic that are suspended in water areas [2]. The main cause of TSS in water areas is partly due to soil scraping or soil erosion that transported to water bodies. TSS influence cloudiness (turbidity) to limit the intake of light that enters the body of water for photosynthesis as well as visibility or appearance from the waters [3]. The existence of TSS can disrupt the balance of aquatic ecosystems which will ultimately adversely affect human survival, such as silting ports, the extinction of some aquatic ecosystems, and environmental damage [4]. The presence of suspended solids may still have a positive impact if it does not exceed the tolerance distribution of water quality standards set by the Ministry of Environment, which is 70 mg / L [5].

Calculations and analyzes need to be done to determine the level of pollution in Lake Tempe because it is related to the life of various types of living things. Based on these factors, an effort is needed to monitor the distribution of TSS from Lake Tempe given the importance of the potential of water that supports various needs. One of the monitoring that can be done is by using remote sensing satellite data and supported by data obtained from field sampling. TSS estimation results with satellite imagery data will result in spatial distribution of TSS values.

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Utilization of remote sensing for water analysis, especially in lake waters has been widely done, but only in certain lakes. Analysis of the water content in the lake can be more easily done if the process is using remote sensing image data because of its advantages being able to analyze a wide area, as well as minimizing field work due to sampling with certain methods. This research is use to map the spatial distribution of TSS in Lake Tempe by using remote sensing imagery and estimate the content of TSS in Lake Tempe by utilizing remote sensing image.

II. Material And Methods

A. Image Processing

Sentinel-2 imagery was corrected up to bottom of atmospheric (BOA). This correction was used to get the new pixel value / digital number. The new digital number will be used to take training area. Regress image corrected inter band. Regression inter band used to get the best determination coefficient. The best coefficient determination will be substituted as *bi* in Eq. (1) of eliminate sun-glint effect. Image correction for Sun-glint effect reduction using formula:

$$r' = r_{\mathrm{i}} - [b_{\mathrm{i}} \times (r_{\mathrm{nir}} - min_{\mathrm{nir}})]. \quad (1)$$

(r'= corrected reflection results of sun-glint; r_{i}= image staked, b_{i}= calibration gradient value, r_{nir}= initial near infrared band reflection value, and min_{nir}= initial near infrared lowest reflection value.)

The algorithm used to obtain the value model is an TSS transformation using Normalized Suspended Material Index algorithm (NSMI) in Fig. 1. NSMI is one of the universal transformations that is often used. The image transformation value for NSMI was calculated using Eq. (2). The closer to -1 indicates that the water is clearer.

$$NSMI = \left(\frac{red\ band + green\ band - blue\ band}{red\ band + green\ band + blue\ band}\right). \quad (2)$$

B. Field Work

Using Stratified Random Sampling method, we planned the total sample. We got total 25 samples spread throughout the sample class. The field stage is carried to take water samples 50 centimeter below the lake's surface. The variable that is made constant in this field stage is the determination of the distance of water sampling below the lake's surface. The results of water sampling were taken to the laboratory to determine the TSS content between samples.

C. Post-Field

The Total Suspended Solid results that have been tested in the laboratory then performed regression using Sentinel-2 imagery that was previously used for sample determination. The relation between the pixel value of the image and the field result produces a regression value. The regression result will be used to test the accuracy of the specified sample. Field map was created based on the field results that were interpolated to generate TSS Content Map of Lake Tempe, South Sulawesi.

D. Flow Chart

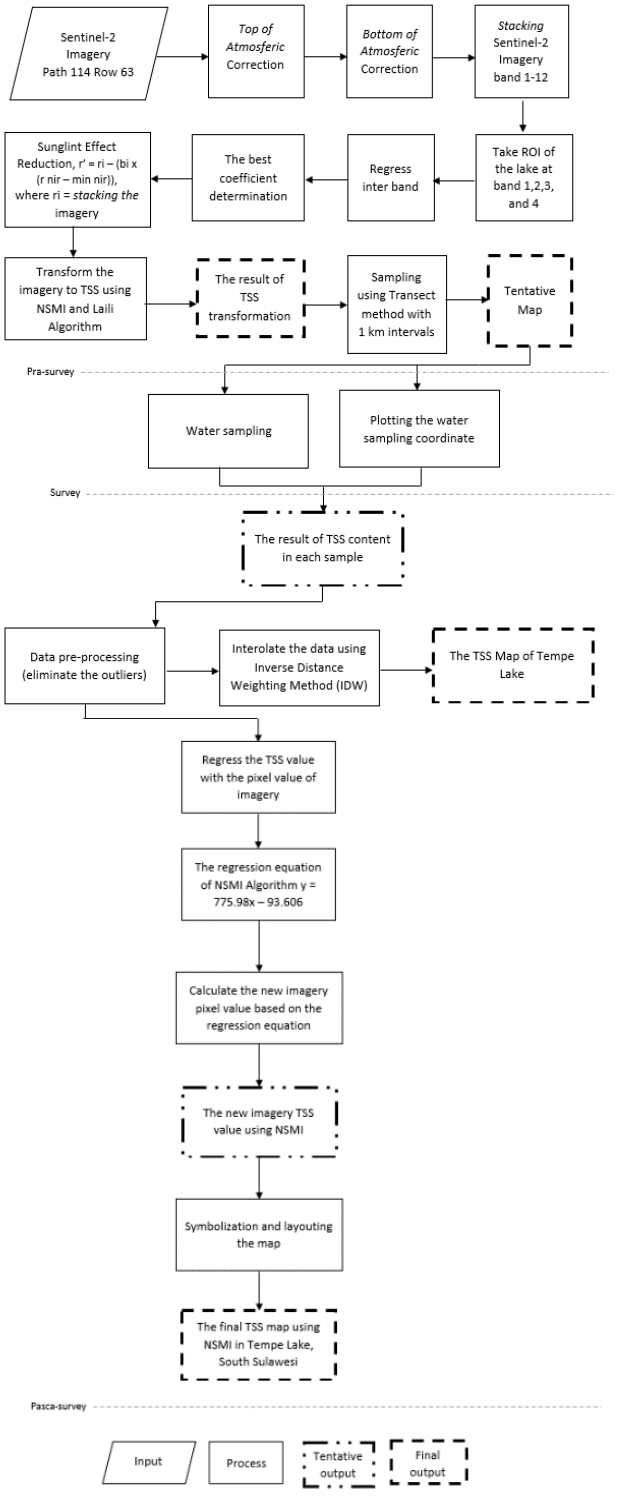


Fig. 1. Flowchart of research process.

III. Results

The field stage is carried out to obtain in situ data on the value of suspended solids. Samples were taken at a depth of 50 cm from sea level. The sampling process is carried out by the transect method using a water sampler. The tool is dipped

in water, after it is fully removed and put in a sample bottle. Each sample bottle is written with the location code.

Sampling was carried out by the transect method. This is seen from the presence of suspended solids that are distributed transversely from shallow water to deep waters. Geotagging photos was taken to help the analysis and represent the data based on the field conditions.

Based on fieldwork that conducted on April 23-24, 2019, only 21 samples were obtained from the 25 samples planned, but some samples were not at the planned sample point location due to the influence of weather and high waves on the day of data collection. Therefore, several new sample points are selected, but still represent variations in values so that they remain representative. Figure 2 is the comparison between the pre-field sample location (plan) and the field sample location (realization). The samples that were successfully taken during field activities were symbolized by a triangle shape and the pre-field plan sample was symbolized by a round shape.

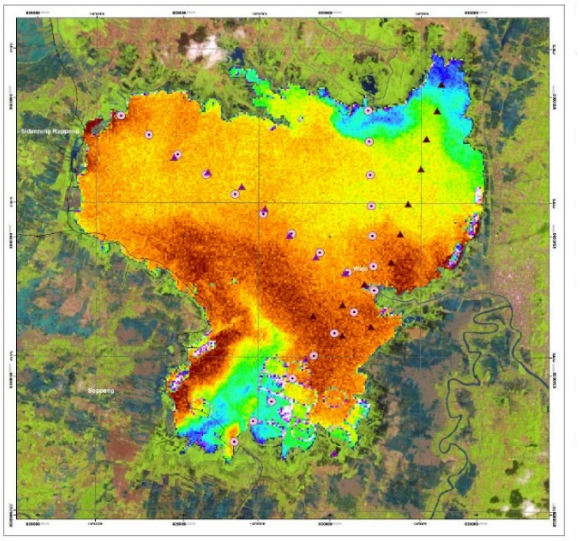
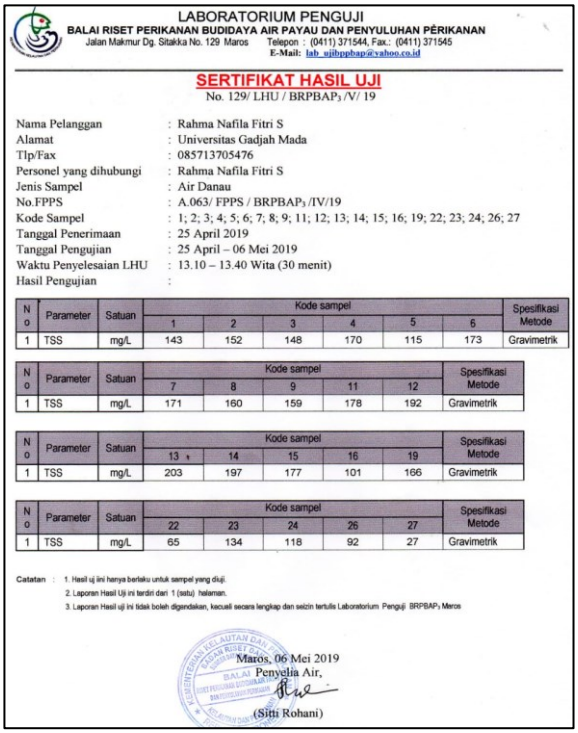


Fig. 2. Comparison between pre-field sample location (plan) and field sample location (realization).

The results of the regression analysis obtained through laboratory results shown in Fig. 3 on 21 samples with the NSMI algorithm. The regression value obtained through the comparison between the TSS value of the NSMI algorithm with the field results obtained was 0.1194. In theory, the results of the NSMI analysis has low correlation or relationship with the TSS values in the field. However, based on its distribution in the field, the distribution of TSS between NSMI and the field has a similar pattern. Low corerlation between TTS indeks and TSS value in the field because range index NSMI around –1 to 1, while the field data from laboratory results show the true of TSS values and have very high values. So, the value of NSMI has to transformed by using the regression equation to make the true TSS value of NSMI method.

Laboratory tests were conducted at the *Laboratorium Penguji Balai Riset Budidaya Air Payau dan Penyuluhan Ikan Maros* where 20 samples were tested. Laboratory test shows the result that the minimum TSS value is 115 mg/L and maximum value of TSS is 203 mg/L (shown in Table I). Statistical tests were performed using regression techniques. Regression makes it possible to produce formulas by considering the best independent variables from some of the variables tested. The dependent variable used is laboratory test results in mg/L units. The regression statistical test uses the value of significance 5%. Statistical test results show that the NSMI transformation has comparable results with field results because it has a positive regression value.



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Kode Sampel : 1; 2; 3; 4; 5; 6; 7; 8; 9; 11; 12; 13; 14; 15; 16; 19; 22; 23; 24; 26; 27
Tanggal Penerimaan : 25 April 2019
Tanggal Pengujian : 25 April – 06 Mei 2019
Waktu Penyelesaian LHU : 13.10 – 13.40 Wita (30 menit)
Hasil Pengujian :

No	Parameter	Satuan	Kode sampel						Spesifikasi Metode
			1	2	3	4	5	6	
1	TSS	mg/L	143	152	148	170	115	173	Gravimetrik

No	Parameter	Satuan	Kode sampel					Spesifikasi Metode
			7	8	9	11	12	
1	TSS	mg/L	171	160	159	178	192	Gravimetrik

No	Parameter	Satuan	Kode sampel					Spesifikasi Metode
			13	14	15	16	19	
1	TSS	mg/L	203	197	177	101	166	Gravimetrik

No	Parameter	Satuan	Kode sampel					Spesifikasi Metode
			22	23	24	26	27	
1	TSS	mg/L	65	134	118	92	27	Gravimetrik

Catatan : 1. Hasil uji ini hanya berlaku untuk sampel yang diuji.
2. Laporan Hasil Uji ini terdiri dari 1 (satu) halaman.
3. Laporan Hasil uji ini tidak boleh digandakan, kecuali secara lengkap dan seizin tertulis Laboratorium Penguji BRPBAP$_3$ Maros

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(Siti Rohani)

Fig. 3. Result from laboratory-tested field samples.

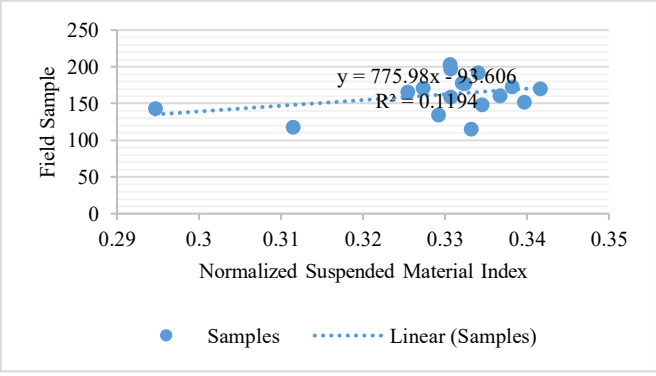

Fig. 4. Regression between model data NSMI with TSS field data.

Accuracy test compares the value of the model data of suspended solid load with the value between the suspended solids field data. TSS estimation model results based on regression results in the form of band ratios are tested for its accuracy using Standard Error of Estimate (SE). The calculation of TSS estimation model accuracy is done using a significance level of 95%, which is calculated using the upper range, lower range, maximal error, and minimum error.

The Standard Error of Estimate (SE) value indicates the accuracy of TSS estimation. The smaller the value of the SE indicates that the estimation results will be more accurate. Based on the calculation results Fig. 4 of the accuracy test, it can be seen that the resulting SE value is 24.43 which indicates that the TSS estimation using NSMI is experiencing the possibility of a true deviation of 24.43 because it follows the mg/L unit results from the field.

Table I. Comparison between TSS NSMI model and TSS field result.

Sample Number	TSS NSMI on Sentinel Imagery	TSS on Field
1	135.024185	143
2	169.962143	152
3	165.932297	148
4	171.496292	170
5	164.945572	115
6	168.796494	173
7	160.406708	171
8	167.670029	160
9	162.996841	159
10	164.088821	178
11	165.590958	192
12	162.914993	203
13	163.013535	197
14	164.295151	177
15	158.926117	166
16	161.817947	134
17	148.104919	118
18	135.024185	143
19	169.962143	152
20	165.932297	148
21	171.496292	170
22	164.945572	115
23	168.796494	173
24	160.406708	171

IV. Conclusion

Spatial distribution mapping of Total Suspended Solid (TSS) at Lake Tempe can be accessed through remote sensing imagery. TSS distribution at Lake Tempe, South Sulawesi showed various value parallel with the level of sedimentation which is more sedimentation has the higher TSS value. Higher TSS value located at the side of the lake which has more sedimentation level. Lower TSS value located at the centre of the lake which has less sedimentation level and deeper lake.

TSS value estimation for freshwater, especially Tempe Lake, using remote sensing imagery depends on the image characteristic such as acquisition date, level of correction, and index used. It can be seen from the difference visualization between before and after field measurements.

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