

IOP_Conf._Ser._Earth_Environ.
_Sci._807_0320051.pdf
by

Submission date: 12-May-2022 09:13PM (UTC+0700)

Submission ID: 1834646229

File name: IOP_Conf._Ser._Earth_Environ._Sci._807_0320051.pdf (977.34K)

Word count: 2144

Character count: 10401

Algorithm of estimation suspended sediments concentration in Bili-Bili Reservoir

Sitti Nur Faridah, Mahmud Achmad, Samsuar and Fatimah R. Tantu

Agricultural Engineering Study Program, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

E-mail: faridah_sn@agri.unhas.ac.id

Abstract. The Bili-Bili Reservoir is located in the middle of the Jeneberang watershed in South Sulawesi Province, which was built for flood control, irrigation, raw water supply, and hydroelectric power plants. However, in the latest development, there has been a decline in utilization of the reservoir service function due to changes in the catchment area condition because of sediment. Estimation of sediment concentration in the Bili-bili reservoir was analyzed using spectrometer data. Estimation of Total Suspended Sediment (TSS) using a spectrometer by reflectance testing of the ratio between bands with various regression equations. Algorithm estimation of TSS concentration based on spectrometer measurements provides a coefficient of determination (R^2) of 0.800 and an RMS error of 0.088, with a 3rd order polynomial equation for the green/red bands ratio: $y = 62.667x^3 - 154.328x^2 + 121.27x - 29.902$.

3 Introduction

Bili-Bili reservoir is located in the middle part of the Jeneberang Watershed, between $5^{\circ}11'8''$ - $5^{\circ}20'41''$ LS and $119^{\circ}34'30''$ - $119^{\circ}56'54''$ BT, and one of the largest reservoirs in South Sulawesi. This reservoir was inaugurated in 1999, which was built with the aim of flood control, meeting irrigation water needs, raw water supply, and hydroelectric power. Bili-Bili reservoir has a catchment area of 384.4 km^2 with a planned operating life of 50 years [1]. However, in its development, there has been a decline in the use of reservoir service function due to changes in conditions of reservoir catchment area due to erosion, which is caused by changes in land use and also an avalanche of caldera wall of Mount Bawakaraeng in 2004 which is located upstream of Jeneberang watershed. Potential for sediment due to landslides flowing downstream when high rainfall intensity results in silting the reservoir, which in turn reduces the operating life of the reservoir and threatens the sustainability of reservoir function [2].

Observations of suspended sediments were carried out to determine water quality in waters because a high Total Suspended Sediment (TSS) value indicates a high level of pollution and can inhibit light penetration into the water [3]. The TSS concentration can be analyzed using a spectrometer. A spectrometer is an optical instrument for observing spectral lines of light and measuring the wavelength and intensity of an object. The spectrometer can be used to find out the content of a sample by passing light on the test medium, then analyzing the composition of wavelength light after passing through the medium [4].



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd

2. Methods

This study used water samples at 54 points of the Bili-bili reservoir and analyzed them using a spectrometer. The concentration of total suspended sediment (TSS) of water samples was calculated by the evaporation method. Model of relationship between TSS concentration in situ and the best reflectance value of spectrometer data was obtained from regression analysis results. The development of a model to estimate TSS concentrations was carried out at the bands' ratio reflectance. The band ratio used adapt wavelength of band ratio in the study of [5], namely band 2 (blue), band 3 (green), and band 4 (red).

Table 1. The regression equation for the relationship model.

No	Relationship model	Equation model
1.	Linear	$y = a + bx$
2.	Exponential	$y = a * \exp(bx)$
3.	Polynomial orde 2	$y = a + b * x^2 + b_1 * x$
4.	Polynomial orde 3	$y = a + b * x^3 + b_1 * x^2 + b_2 * x$
5.	Logarithmic	$y = a * \ln(x) + b$
6.	Power	$y = a * x^b$

Source: [6].

The relationship model developed is an empirical model using a regression equation between TSS concentration in situ and reflectance value of band ratio in the blue, green, or red band. Further analysis was carried out on the model with the highest coefficient of determination and smallest RMS error. Coefficient determination is criteria of model appropriate with a value of 0 to 1, the value of R^2 as a measure of closeness relationship between the y variable as a dependent variable and the x variable as an independent variable (table 1). While the RMS error value is close to zero, indicating that the estimation model is getting better.

$$RMS\ error = \sqrt{\frac{(\text{in situ value} - \text{estimated value})^2}{n-2}} \quad (1)$$

where:

In situ value: TSS concentration that measured;

Estimated value: TSS concentration from model development;

n: the amount of data.

Data validation was carried out using a two-way mean difference test or t-test [7].

$$H_0: \mu_1 = \mu_2 \quad \text{dan} \quad H_1: \mu_1 \neq \mu_2$$

where:

H_0 : if mean TSS concentration in situ is the same as mean TSS concentration of estimation;

H_1 : if mean TSS concentration in situ is not the same as mean TSS concentration of estimation;

μ_1 : mean in situ TSS concentration;

μ_2 : mean TSS concentration of estimation.

3. Results and discussion

3.1. Algorithm of estimation TSS concentration

The average TSS concentration in situ was obtained at 0.2582 g/l, with the lowest concentration of 0.0360 g/l at 119°35'342" EL and 5°15'956" SL, and the highest concentration was 1.2280 g/l at 119°36'134" EL and 5°15'507" SL. Based on the analysis of spectrometer measurement data, the reflectance value that has the best correlation coefficient with TSS concentration value in situ is selected, namely the blue band ($\lambda = 478$ nm), the green band ($\lambda = 555$ nm), and the red band ($\lambda = 648$ nm). The relationship between TSS concentrations in situ using bands ratio, namely blue/green, blue/red, and green/red, obtained results as shown in table 2.

Table 2. The TSS concentration estimation algorithm uses a bands ratio spectrometer on various regression equations.

Bands ratio	Relationship model	Equations	R ²	RMS error
Blue/green	Exponential	$TSS = 4.973e^{-3.48(b/g)}$	0.139	0.183
	Linear	$TSS = -1.611(b/g) + 1.759$	0.381	0.173
	Logarithmic	$TSS = -1.49\ln(b/g) + 0.145$	0.433	0.166
	Polynomial orde 2	$TSS = 6.515(b/g)^2 - 13.23(b/g) + 6.89$	0.559	0.146
	Polynomial orde 3	$TSS = -12.86(b/g)^3 + 39.72(b/g)^2 - 41.3(b/g) + 14.62$	0.565	0.145
	Power	$TSS = 0.151(b/g)^{-3.22}$	0.156	0.173
Blue/red	Eksponensial	$TSS = 2.179e^{-2.63(b/r)}$	0.128	0.174
	Linear	$TSS = -1.386(b/r) + 1.534$	0.457	0.162
	Logarithmic	$TSS = -1.05\ln(b/r) + 0.160$	0.508	0.155
	Polynomial orde 2	$TSS = 2.809(b/r)^2 - 5.724(b/r) + 3.114$	0.546	0.148
	Polynomial orde 3	$TSS = -2.357(b/r)^3 + 8.239(b/r)^2 - 9.700(b/r) + 4.017$	0.548	0.148
	Power	$TSS = 0.159(b/r)^{-2.05}$	0.149	0.163
Green/red	Eksponensial	$TSS = 3.186e^{-2.84(g/r)}$	0.053	0.203
	Linear	$TSS = -1.867(g/r) + 2.099$	0.295	0.185
	Logarithmic	$TSS = -1.76\ln(g/r) + 0.228$	0.338	0.179
	Polynomial orde 2	$TSS = 12.05(g/r)^2 - 23.51(g/r) + 11.67$	0.547	0.148
	Polynomial orde 3	$TSS = 53.52(g/r)^3 - 131.1(g/r)^2 + 102.5(g/r) - 24.67$	0.581	0.197
	Power	$TSS = 0.183(g/r)^{-2.85}$	0.069	0.196

The relationship between TSS concentration in situ and bands ratio, which has the best correlation, is the polynomial equation of order 3, green/red bands ratio. The value of coefficient determination (R^2) is 0.581, and the RMS error is 0.197 as shown in figure 1. The value of R^2 is close to 1, meaning that the closer the observation point is to the regression line and the model is getting better [8]. Green/red bands ratio polynomial algorithm model equation:

$$\text{TSS} = 53.52(\text{g/r})^3 - 131.1(\text{g/r})^2 + 102.5(\text{g/r}) - 24.67 \quad (2)$$

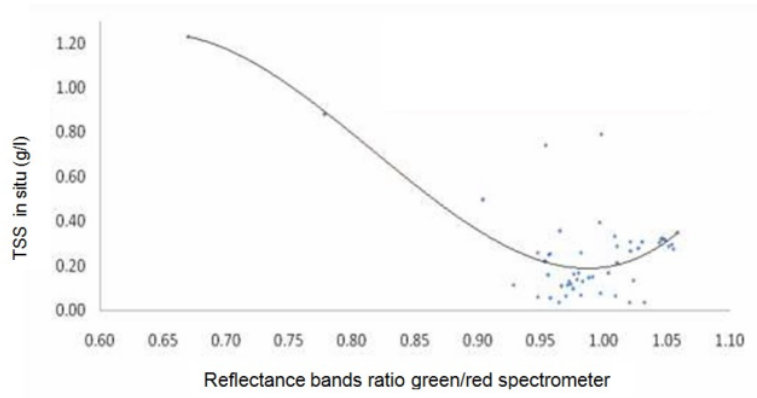


Figure 1. Relation of spectrometer's green/red band ratio and TSS concentration in situ.

In general, the TSS concentration estimated tends to be almost the same as the TSS concentration in situ, with a concentration value of relatively higher in TSS of estimated (figure 2).

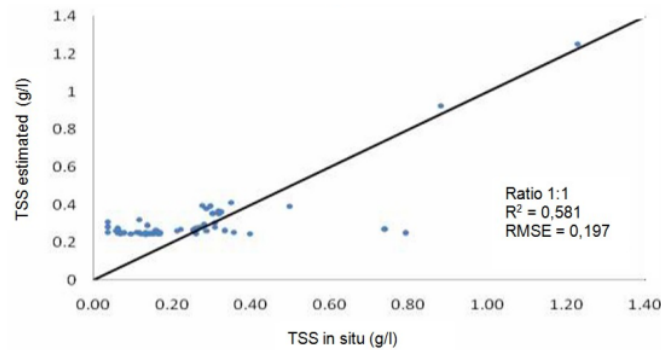


Figure 2. Relationship between TSS in situ and TSS estimation algorithm.

3.2. Testing and validation of TSS concentration data

To identify the best parameter model, outlier data must be detected by removing the outlier data [9]. Outlier analysis using t-test residual data. Figure 3 shows that of the 54 data, there are two outlier data, namely the 14 and 21 data, which causes the resulting coefficient of determination to below (0.581). The two data are excluded. The new relationship obtained from the regression results, R^2 of 0.800 and the RMS error of 0.088, as shown in figure 4 and the resulting equation is:

$$\text{TSS} = 62,667(\text{g/r})^3 - 154,328(\text{g/r})^2 + 121,27(\text{g/r}) - 29,902 \quad (3)$$

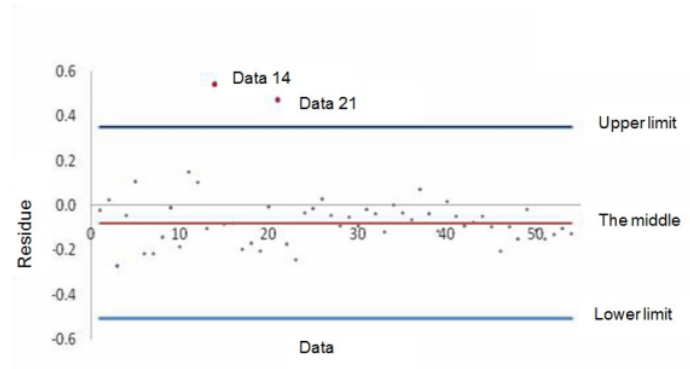


Figure 3. Outlier analysis plot.

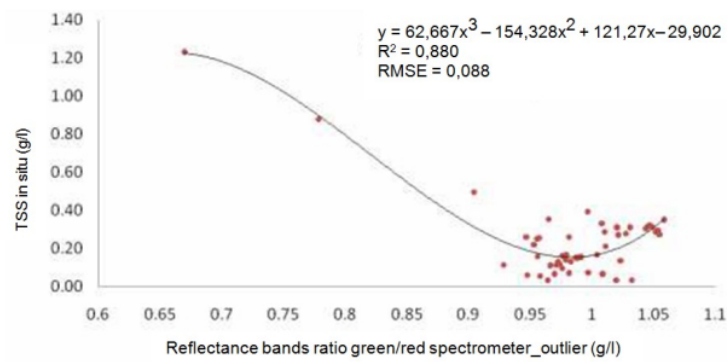


Figure 4. Relation of spectrometer's green /red bands ratio and TSS concentration in situ.

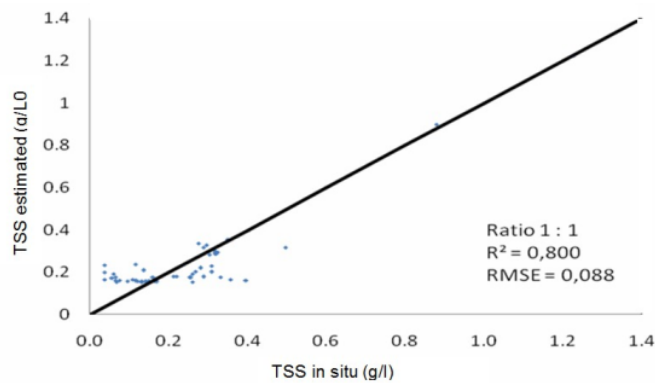


Figure 5. Relationship between TSS concentrations in situ and estimated TSS.

The t-test is carried out on variables that have no relationship to influence each other. Still, the relationship between the middle value of a variable is significantly different from the mean value of other variables. A two-way t-test was carried out to determine the median value of one variable against the median value of the other variables. The results of the t-test are presented in table 3.

Table 3. The results of the t-test of the spectrometer processing data.

Variable	t-count	t-table	information
TSS <i>in situ</i> and TSS estimated	0.385196991	2.008559072	Accept H_0

The results of the t-test show that t-count is in the interval between \pm t-table [(-) t-table < t-count < (+) t-table], so it can be said to accept H_0 . Accepted H_0 means that there is no significant difference between the middle-value TSS concentration *in situ* and estimated TSS so that the algorithm resulting from the development of the model from the green/red bands ratio of spectrometer data can be used to estimate TSS concentration in the water bodies of the Bili-Bili reservoir.

4. Conclusion

The algorithm for estimating TSS concentration of water bodies in the bili bili reservoir is obtained from results of the 3rd order polynomial regression between TSS *in situ* and green/red band ratio with a coefficient determination (R^2) 0.800 and RMSE 0.088, has the equation: $y = 62,667x^3 - 154,328x^2 + 121,27x - 29,902$

References

- [1] Jeneberang River Basin Development Project 2004 Country Report- Indonesia. Indonesia
- [2] Asrib A R Purwanto Y J and Sukandi S, 2011 Impact of caldera wall avalanche on sedimentation level in Bili-bili reservoir, South Sulawesi Province *J. Hidrolitan* **2**, 3 p. 135–146
- [3] Ritchie J C and Cooper C M, 1988 Comparison of measured suspended sediment concentrations with suspended sediment concentrations estimated from Landsat MSS data *TitleREMOTE Sens.* **9**, 3 p. 379–387
- [4] Welz B and Sperling M, 2008 *Atomic absorption spectrometry* John Wiley & Sons
- [5] Wouthuyzen S *et al.*, 2011 Measurement of surface salinity of Jakarta Bay by sensing sea color using multi-temporal data from Landsat-7 ETM + satellite imagery *Mar Res Indones* **36**, 2 p. 51–70
- [6] Purwanto S, 2004 *Statistics for Modern Economics and Finance* 2nd ed. Jakarta: Salemba Empat
- [7] Walpole R E, 1995 *Introduction to statistics* 3rd ed. Jakarta: PT. Gramedia Pustaka Utama
- [8] Aunuddin, 1989, Data Analysis. Ministry of Education and Culture, Directorate General of Higher Education, Inter-University Center for Life Sciences IPB, Bogor
- [9] Aulia R S and Atok R M, 2017 Determination of the optimal length of outlier-free time series data using the window time method *J. Sains Dan Seni ITS* **6**, 1 p. D129–D136

ORIGINALITY REPORT

18%

SIMILARITY INDEX

16%

INTERNET SOURCES

9%

PUBLICATIONS

7%

STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Pennsylvania College of Technology Student Paper	4%
2	journalijdr.com Internet Source	3%
3	earchive.tpu.ru Internet Source	3%
4	adoc.pub Internet Source	2%
5	ci-tech.upnjatim.ac.id Internet Source	1%
6	text-id.123dok.com Internet Source	1%
7	litpam.com Internet Source	1%
8	Xi Chen, Junfeng Zhao, Liping Yu, Chunying Rong, Chengzhi Li, Shixun Lian. "A white light emitting phosphor Sr _{1.5} Ca _{0.5} SiO ₄ :Eu ³⁺ , Tb ³⁺ , Eu ²⁺ for LED-based near-UV chip:	1%

Preparation, characterization and luminescent mechanism", Journal of Luminescence, 2011

Publication

9	aesapconference.org Internet Source	1 %
10	courseprojecthelp.blogspot.com Internet Source	1 %
11	www.sciencegate.app Internet Source	1 %
12	M. Anji Reddy. "Comparison of IRS-IB LISS-IIA pixel array sizes for estimating suspended solids concentration in Hussain Sagar lake, Hyderabad, India - a statistical approach", International Journal of Remote Sensing, 12/1/1994 Publication	<1 %
13	eprints.walisongo.ac.id Internet Source	<1 %
14	repository.unhas.ac.id Internet Source	<1 %

Exclude quotes On

Exclude matches < 5 words

Exclude bibliography On