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Application of New Empirical Algorithm in Coastal Waters of Padanggalak Beach to Detect Total Suspended Solid Value

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ABSTRACT

Total Suspended Solid is one of the important indicators in the physical parameters to determine the quality status of the waters studied. In this case, researchers will create a new algorithm to detect TSS values at Padanggalak Beach, where the beach is the estuary of the Ayung Watershed. The creation of the algorithm that has been carried out by several researchers took the case in coastal waters, so that the algorithm will cause a fairly high difference in value when applied to other coastal areas. Coastal areas in each place have different characteristics, where coastal areas are dynamic areas, influenced by various factors including climate, weather, wind direction, ocean currents and characteristics of the use of the surrounding environment. Field data taken in the form of seawater samples were then tested in the laboratory to produce TSS concentration values at each sample point. Field observations for TSS sampling in the coastal waters of the Ayung DAS estuary located at Padanggalak Beach were carried out on Wednesday, August 14, 2024 at 08.00 - 10.30 WITA. The form of the new algorithm equation produced along with its correlation level is TSS = -25.096 x (B6/B11) + 42.415, for TSS estimation at Padanggalak Beach. Based on the results of the analysis of the determination coefficient of the New Empirical TSS Algorithm with Insitu TSS, the R^2 result was 0.6812. This shows that the results of in situ data and the results of satellite image processing using the New Empirical Algorithm are considered to have a strong correlation relationship, which means that the TSS results from the empirical algorithm are quite in accordance with the TSS results in the field at the Ayung DAS Estuary (Padanggalak Beach).

Keywords: Ayung Watershed, new empirical algorithm, Padanggalak Beach, Sentinel-2A, total suspended solid.

INTRODUCTION

Total Suspended Solid is one of the important indicators in the physical parameters to determine the quality status of the waters studied. The value of suspended solids or Total Suspended Solid and the direction of its distribution in coastal areas are influenced by two factors, namely factors originating from the influence of land and factors originating from the influence of the ocean. Factors originating from land (rivers) include industrial waste, rainfall, river discharge and changes in land use. Factors originating from the ocean include sediment transport, ocean currents, wind direction and speed, tides and waves.

Rainfall is one of the climate elements that causes erosion rates that cause sedimentation accumulation. High rainfall has an effect on increasing sedimentation in the form of high total suspended solids (TSS) values, which have an impact on decreasing river water quality. Sedimentation in the form of suspended solids causes many water problems such as river shallowing, coastal erosion, and changes in the coastline. Another impact that can arise is the occurrence of turbidity in river water which interferes with the penetration of sunlight into the waters [1] .

The characteristics of suspended loads produced by the River Basin Area (DAS) are related to the water discharge and the season that occurs. Based on research from [2], the correlation between water discharge and total volume concentration of suspended particles based on satellite shows a high correlation. The peak water discharge in a watershed is always associated with a high value of total volume concentration of suspended particles. At a certain water discharge, the size of suspended sediment grains will be larger if the flow is more erratic than if the flow is persistent.

Ocean currents are one of the physical oceanographic factors that influence the process of sedimentation (addition) and abrasion (reduction) of land. The presence of physical oceanographic factors affects the distribution of Total Suspended Solid (TSS) in water areas. According to [3], high current speeds cause TSS values to be high, while low current speeds tend to precipitate suspended sediment and cause sedimentation.

The ebb and flow that occurs in ocean waters affects the rate of distribution of suspended solids. During high tide, the sea water elevation is higher so that the river estuary will be dominated by sea water. During low tide, the sea water elevation becomes lower so that river water dominance occurs in the estuary area which carries suspended solids and affects the existing estuary ecosystem [4].

The presence of physical oceanographic factors such as currents and waves causes the distribution of suspended particles in the sea. The relationship between sediment and increasing wave height is that the larger the grain size, the larger the waves that occur in the area. Large waves will affect the high concentration of suspended particles in the waters because there will be relatively high stirring [5].

The creation of a new empirical algorithm in detecting total suspended solid values in coastal waters was carried out at the Ayung River Basin Estuary (Padanggalak Beach). The modeling of the new algorithm at Padanggalak Beach was carried out by utilizing the reflectance values generated from the recording of image data used in the analysis, namely Sentinel-2A image data. Researchers also analyzed field samples based on conditions that support the implementation of activities. The modeling of the algorithm is expected to be appropriate and close to the value of the results between the analysis of satellite image data and the analysis of sample tests carried out in the field.

The Ayung River, which stretches 68.5 kilometers, is the longest river on the island of Bali. Human activities around this river, such as agriculture, livestock, settlements, and household industries, have the potential to produce organic waste that enters the river water. Daily human activities, including cleaning themselves, cooking, and other environmental activities, can also contribute to river pollution [6]. Based on the results of research conducted by [7] which was conducted downstream of the Ayung River, it showed that the content of suspended solids and dissolved solids in the afternoon was higher than in the morning.

RESEARCH METHODS

Materials

Field data taken in the form of seawater samples were then tested in the laboratory to produce TSS concentration values at each sample point. Field observations for TSS sampling in the coastal waters of the Ayung DAS estuary located at Padanggalak Beach were carried out on Wednesday, August 14, 2024 at 08.00 - 10.30 WITA. The coordinate data for the sampling points and TSS values at each sampling point are shown in Table 1.

Table 1. Distribution of Seawater Sampling Coordinates at the Ayung River Basin Estuary (Padanggalak Beach)

No	Sampling Point	Longitude	Latitude	TSS Value (mg/L)
1	1D	115.26649	-8.66092	19.5
2	1E	115.26721	-8.65973	17
3	1K	115.27161	-8.65716	19
4	1L	115.27217	-8.65686	18.5
5	1S	115.27786	-8.65332	16.5
6	1T	115.27905	-8.65332	18
7	1U	115.28027	-8.65313	18.5
8	1V	115.28118	-8.65238	20

No	Sampling Point	Longitude	Latitude	TSS Value (mg/L)
9	1W	115.28241	-8.65135	14.5
10	1X	115.28338	-8.64999	14.5
11	2B	115.26583	-8.66333	13.5
12	2H	115.27944	-8.65306	17
13	2I	115.28139	-8.65139	9
14	2J	115.28333	-8.65056	11
15	2K	115.28472	-8.64889	8
16	2L	115.28667	-8.64722	11
17	2M	115.28861	-8.64556	13
18	2N	115.29056	-8.64417	13
19	2O	115.29194	-8.64250	11

The satellite image data used in this study was adjusted to the data on the same day when conducting field observations. Information regarding Sentinel-2 Satellite Image Data is shown in Table 2.

Table 2. Sentinel-2 Satellite Imagery Data Information

No	Recording Date	Data Types	Data Recording Time (UTC)	Cloud Cover (%)
1	Wednesday, August 14, 2024	Sentinel 2A Level 2A	02:16:01.024	11,6

The downloaded file must be extracted first so that it can be opened in the SNAP application. The MTD_MSIL2A code indicates that the file is metadata from the Sentinel-2A Multi Spectral Image satellite imagery with level 2A. Level 2A data is Bottom of Atmosphere (BOA) reflectance data that has been systematically corrected from Top of Atmosphere (TOA). Based on this information, it can be seen that the Sentinel-2A Level 2A image data is the result of recording on Wednesday, August 14, 2024 at 02:16:01.024 UTC. Universal Time Coordinated (UTC) needs to be converted into Central Indonesian Time (WITA) so that the recording time on the image data is added with (UTC+08:00). The recording time in the studied area shows 10:16:01.024 WITA so it can be concluded that the image data recording was carried out in the morning.

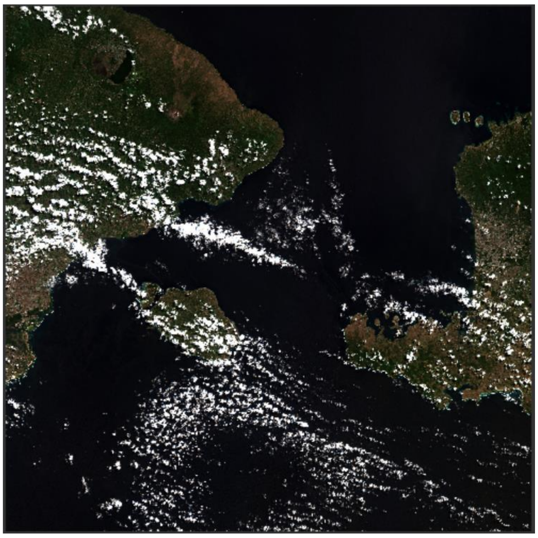

Figure 1. Red Green Blue (RGB) Combination Visualization on Recording Data Date August 14, 2024

Methods

The creation of the Total Suspended Solid algorithm utilizes the reflectance values contained in the image channel. The equation for compiling the algorithm is compiled based on a combination of each channel applied in the form of simple mathematical operations including subtraction, addition, division and multiplication. Logarithmic, linear, and exponential approaches are then applied to obtain the regression method algorithm equation. The determination of the algorithm takes into account the best results from the regression analysis of the image channel values used.

A statistical process that has the benefit of knowing the comparison between field analysis data and satellite image processing analysis data is part of the validation test of algorithm estimation with field data. The comparison is carried out to find the correlation value so that the field test data with the analysis data with the algorithm that has been created does not have a significant difference in value. According to [8], the calculation of error values or error values is needed to find the value of the truth of an algorithm application on image data.

Table 3. Interpretation of Correlation Coefficient

Coefficient Interval	Connection Level
0.00	There is no correlation
0.00 – < 0.25	Very Weak Correlation
0.25 – < 0.50	Correlation Sufficient
0.50 – < 0.75	Strong Correlation
0.75 – 0.99	Very Strong Correlation
1	Perfect Correlation

Source: [9]

Data Analysis

The spatial resolution of each channel of Sentinel-2A image data has different resolutions so that in the processing process, the main thing that must be done is to carry out the resampling process in the SNAP application. The resolution of Sentinel-2 image data is 60 m, 20 m and 10 m. Resampling of Sentinel-2 image data provides benefits so that data that has different resolutions is equalized to produce the highest resolution in the data, namely 10 m resolution so that the image quality of Sentinel-2 image data becomes better.

Sentinel Application Platform (SNAP) is a special software provided by the European Space Agency (ESA) to process Sentinel 1, Sentinel 2, and Sentinel 3 satellite imagery data with each toolbox based on the type of image data to be processed. The toolbox is a device in the SNAP application that is developed in providing tools to visualize, process data sets and analyze each type of Sentinel satellite imagery data [10].

Sentinel – 2 Toolbox is dedicated to improving the support of SNAP applications for processing high-resolution optical satellite imagery data. In addition to processing Sentinel - 2A and Sentinel - 2B imagery data, Sentinel - 2 Toolbox can be applied to RapidEye, Deimos, SPOT 1 to SPOT 5 imagery data. Several types of data processing provided in Sentinel - 2 Toolbox are in the form of process algorithms for data resampling, geometric correction, atmospheric correction, and data cropping [11].

Sentinel – 2 Toolbox can also be used by researchers and workers who want to process image data for useful purposes, such as classification of land use changes, vegetation cover, rice fields, ice cover, coastline changes, chlorophyll value estimation, TSS value estimation, or benefits for mapping areas that are potentially affected by natural disasters. The use of the SNAP application with its various benefits and functions has motivated many parties to slowly learn the application so that SNAP is one of the most downloaded applications from various developed and developing countries [12].

In the processing parameter filling column, the output resolution is changed to 10 m because the purpose of this resampling process is to equalize the resolution of each image channel to the highest

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resolution, which is 10 m. The user's success in applying the resampling process to SNAP is indicated by a notification from the application stating that the process has been successful and information about the length of time spent on its application. The amount of time required to carry out the resampling process is influenced by the following factors, such as the size of the type of image data being processed along with the type of laptop or computer specifications used by the user.

Figure 2. Resampling Results on Recording Data Date August 14, 2024

Image data cutting or data subset aims to focus the research area to be studied. The focus area or region to be studied is called the Area of Interest (AOI) [13]. Areas that are not analyzed in the study will be cut according to the area coordinates so as to reduce and save data storage memory and speed up the analysis process. In the pixel coordinates menu column, filling in Scene end X and Scene end Y data is done based on the area that will be used in research or data processing.

Figure 3. Subset Results on Recording Data Date August 14, 2024

In applying the algorithm, Sentinel-2A satellite imagery data is processed first by processing Mask out Land on the SNAP application. This aims to make the results of the algorithm that has been applied more focused on the water area.

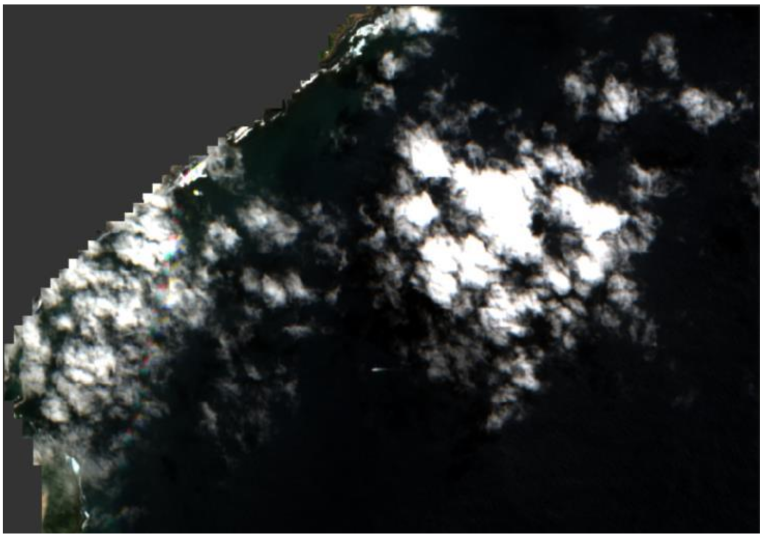

Figure 4. Mask Out Land Results on Recording Data Date August 14, 2024

Overlaying seawater sampling survey coordinate points into mapping is the process of combining or overlaying sampling point data onto an existing base map. The purpose of this process is to visualize and analyze the relationship between sampling point data and geographic or spatial characteristics on the map. This can help in facilitating the understanding and interpretation of data.

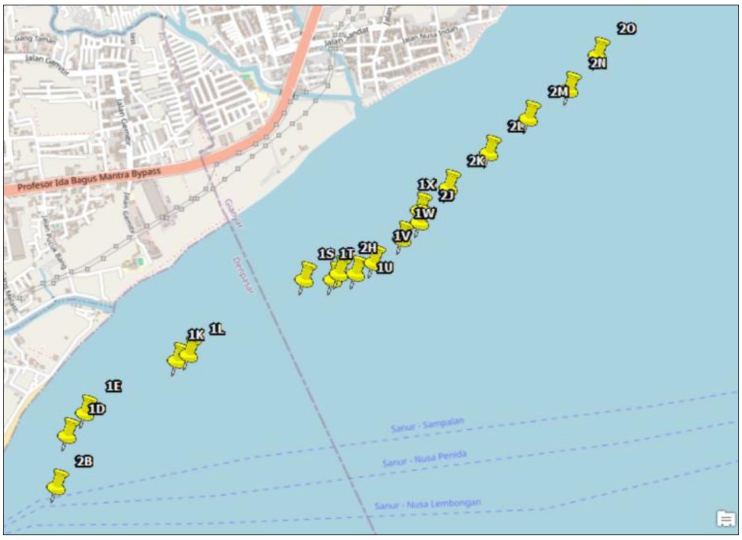

Figure 5. Sea Water Sampling Point at Padanggalak Beach

RESULT AND DISCUSSION

In this study, the channels used are Coastal Aerosol channel (B1), Blue channel (B2), Green channel (B3), Red channel (B4), Vegetation Red Edge channel (B5), Vegetation Red Edge channel (B6), Vegetation Red Edge channel (B7), NIR channel (B8), Vegetation Red Edge channel (B8A), SWIR channel (B11) and SWIR channel (B12) for Sentinel-2. The surface reflectance value of Sentinel-2 imagery is directly obtained by downloading Sentinel-2A satellite imagery. The Remote Sensing Reflectance (Rrs) value of each channel used at the Ayung DAS Estuary location (Padanggalak Beach) is shown in Table 4.

Table 4. Remote Sensing Reflectance (Rrs) Value of the Estuary of the Ayung Watershed

Sample Code	B1	B2	B3	B4	B5	B6	B7	B8	B8A	B11	B12

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1D	0.11060	0.09470	0.09900	0.07060	0.06070	0.05250	0.05250	0.05880	0.05450	0.05270	0.04950
1E	0.11540	0.08860	0.09160	0.07120	0.07880	0.07920	0.08270	0.05760	0.08140	0.07410	0.06510
1K	0.10120	0.10340	0.09440	0.07090	0.06190	0.06100	0.06000	0.08080	0.05520	0.06520	0.05860
1L	0.14280	0.07480	0.07180	0.05050	0.06830	0.06430	0.06790	0.04780	0.07210	0.07240	0.07860
1S	0.07230	0.05900	0.05610	0.03890	0.03710	0.03090	0.03100	0.02990	0.02960	0.02660	0.02370
1T	0.09280	0.08380	0.07500	0.05200	0.05770	0.05080	0.04800	0.05390	0.04550	0.04960	0.03940
1U	0.17980	0.08180	0.09100	0.09720	0.08890	0.09460	0.11270	0.05860	0.13750	0.10150	0.13570
1V	0.09260	0.07780	0.06420	0.04460	0.06540	0.06240	0.06470	0.03790	0.06730	0.06200	0.05510
1W	0.07630	0.06120	0.05710	0.03240	0.03190	0.02620	0.02850	0.02440	0.02840	0.02450	0.02200
1X	0.07430	0.06140	0.05760	0.03240	0.03170	0.02640	0.02600	0.02580	0.02380	0.02330	0.01840
2B	0.09250	0.08460	0.09150	0.07020	0.06050	0.06060	0.05880	0.06010	0.06080	0.05990	0.05690
2H	0.11750	0.07160	0.07380	0.06400	0.06950	0.06760	0.07150	0.04610	0.07610	0.06580	0.06630
2I	0.06470	0.06040	0.05260	0.02970	0.02900	0.02550	0.02440	0.02360	0.02320	0.02080	0.01990
2J	0.08340	0.06880	0.06800	0.05100	0.04930	0.04840	0.05130	0.03490	0.05200	0.04080	0.03960
2K	0.06100	0.05460	0.04740	0.02520	0.02380	0.01960	0.02050	0.01770	0.01840	0.01640	0.01520
2L	0.05210	0.04420	0.03900	0.01990	0.01830	0.01560	0.01520	0.01400	0.01340	0.01270	0.01100
2M	0.05110	0.04570	0.03980	0.02010	0.01790	0.01360	0.01420	0.01320	0.01140	0.01100	0.01000
2N	0.05870	0.05460	0.04650	0.02480	0.02350	0.01970	0.01930	0.01760	0.01730	0.01600	0.01360
2O	0.05500	0.04920	0.04320	0.02530	0.02220	0.01790	0.01680	0.01570	0.01640	0.01380	0.01210

Empirical algorithm modeling of TSS concentration using 11 channels, namely Coastal Aerosol channel (B1), Blue channel (B2), Green channel (B3), Red channel (B4), Vegetation Red Edge channel (B5), Vegetation Red Edge channel (B6), Vegetation Red Edge channel (B7), NIR channel (B8), Vegetation Red Edge channel (B8A), SWIR channel (B11) and SWIR channel (B12). Algorithm modeling uses a linear regression model with in situ TSS concentration values and atmospherically corrected remote sensing reflectance values (Rrs(λ)) as input. In situ TSS concentration values are dependent variables, while Rrs (λ) values are independent variables. The regression model with the highest correlation coefficient (R2) value is selected as the empirical algorithm to be used to estimate TSS concentration values in the Ayung DAS Estuary (Padanggalak Beach). The values of the determination coefficient or correlation coefficient of a single channel and the ratio of two channels are shown in Table 5 and Table 6.

Table 5. Single Channel Determination Coefficient (R^2)

Regression Model	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
TSS = ax +b	0.4836	0.529	0.4638	0.4356	0.575	0.5041
TSS = a*log(x) +b	0.5559	0.5288	0.4817	0.4864	0.5803	0.5315

Regression Model	λ_7	λ_8	λ_{8A}	λ_{11}	λ_{12}
TSS = ax +b	0.4699	0.5191	0.416	0.5449	0.5252
TSS = a*log(x) +b	0.5279	0.5523	0.5047	0.5756	0.5252

Table 6. Two Channel Ratio Determination Coefficient (R^2)

Regression Model	λ_1/λ_2	λ_1/λ_3	λ_1/λ_4	λ_1/λ_5	λ_1/λ_6
TSS = a*(bi/bj) +b	0.1557	0.1005	0.1265	0.389	0.3737
TSS = a*log(bi/bj) +b	0.1544	0.0816	0.1279	0.3789	0.362
TSS = a*(log(bi)/log(bj)) +b	0.1758	0.1348	0.0006	0.0949	0.1391

Regression Model	λ_1/λ_7	λ_1/λ_8	λ_1/λ_{8A}	λ_1/λ_{11}	λ_1/λ_{12}
TSS = a*(bi/bj) +b	0.4099	0.2918	0.3918	0.4916	0.4484
TSS = a*log(bi/bj) +b	0.3951	0.2642	0.395	0.5037	0.4597
TSS = a*(log(bi)/log(bj)) +b	0.2084	0.0376	0.2662	0.363	0.3674

Regression Model	λ_2/λ_3	λ_2/λ_4	λ_2/λ_5	λ_2/λ_6	λ_2/λ_7
TSS = a*(bi/bj) +b	0.1276	0.378	0.5027	0.4526	0.4578
TSS = a*log(bi/bj) +b	0.1303	0.3345	0.4832	0.4349	0.4231

TSS = a*(log(bi)/log(bj)) +b	0.0905	0.2228	0.3894	0.3434	0.3138

Regression Model	λ_2/λ_8	λ_2/λ_{8A}	λ_2/λ_{11}	λ_2/λ_{12}
TSS = a*(bi/bj) +b	0.533	0.4217	0.5279	0.4709
TSS = a*log(bi/bj) +b	0.5358	0.4003	0.5233	0.4437
TSS = a*(log(bi)/log(bj)) +b	0.4978	0.2911	0.4403	0.3188

Regression Model	λ_3/λ_4	λ_3/λ_5	λ_3/λ_6	λ_3/λ_7
TSS = a*(bi/bj) +b	0.4292	0.5073	0.4455	0.454
TSS = a*log(bi/bj) +b	0.3996	0.5024	0.4491	0.4387
TSS = a*(log(bi)/log(bj)) +b	0.2807	0.4019	0.3633	0.3401

Regression Model	λ_3/λ_8	λ_3/λ_{8A}	λ_3/λ_{11}	λ_3/λ_{12}
TSS = a*(bi/bj) +b	0.571	0.4177	0.5366	0.4723
TSS = a*log(bi/bj) +b	0.5807	0.4134	0.5481	0.4611
TSS = a*(log(bi)/log(bj)) +b	0.5374	0.3118	0.4772	0.3437

Regression Model	λ_4/λ_5	λ_4/λ_6	λ_4/λ_7	λ_4/λ_8	λ_4/λ_{8A}	λ_4/λ_{11}	λ_4/λ_{12}
TSS = a*(bi/bj) +b	0.1616	0.2831	0.3056	0.2441	0.32	0.5041	0.4215
TSS = a*log(bi/bj) +b	0.1799	0.2948	0.3143	0.2613	0.3328	0.5054	0.4167
TSS = a*(log(bi)/log(bj)) +b	0.1484	0.2302	0.2618	0.1131	0.2805	0.437	0.3285

Regression Model	λ_5/λ_6	λ_5/λ_7	λ_5/λ_8	λ_5/λ_{8A}	λ_5/λ_{11}	λ_5/λ_{12}
TSS = a*(bi/bj) +b	0.2122	0.2325	0.0029	0.2611	0.5119	0.3555
TSS = a*log(bi/bj) +b	0.2107	0.2238	0.015	0.249	0.5126	0.3371
TSS = a*(log(bi)/log(bj)) +b	0.1303	0.1518	0.0001	0.172	0.4542	0.2207

Regression Model	λ_6/λ_7	λ_6/λ_8	λ_6/λ_{8A}	λ_6/λ_{11}	λ_6/λ_{12}
TSS = a*(bi/bj) +b	0.0913	0.0334	0.2163	**0.6812**	0.3654
TSS = a*log(bi/bj) +b	0.0909	0.0105	0.21	0.6741	0.3422
TSS = a*(log(bi)/log(bj)) +b	0.103	0.0159	0.1604	0.6189	0.2199

Regression Model	λ_7/λ_8	λ_7/λ_{8A}	λ_7/λ_{11}	λ_7/λ_{12}
TSS = a*(bi/bj) +b	0.0563	0.2218	0.5493	0.376
TSS = a*log(bi/bj) +b	0.0251	0.2248	0.535	0.3599
TSS = a*(log(bi)/log(bj)) +b	0.0306	0.1782	0.3799	0.23

Regression Model	λ_8/λ_{8A}	λ_8/λ_{11}	λ_8/λ_{12}	$\lambda_{8A}/\lambda_{11}$	$\lambda_{8A}/\lambda_{12}$	$\lambda_{11}/\lambda_{12}$
TSS = a*(bi/bj) +b	0.031	0.191	0.1402	0.0752	0.2467	0.0281
TSS = a*log(bi/bj) +b	0.07	0.2162	0.1676	0.0908	0.2477	0.0366
TSS = a*(log(bi)/log(bj)) +b	0.0903	0.1963	0.1369	0.0177	0.111	0.0217

Based on the results of the analysis that has been done, the highest coefficient of determination (R2) value was obtained in the Sentinel-2A satellite image analysis data with in-situ TSS test data, which was 0.6812 with a linear regression type on the graph. The form of the New TSS Algorithm equation obtained was TSS = -25.096 x (B6/B11) + 42.415. The algorithm modeling is considered good if it meets the criteria of R^2 value> 0.5 [14].

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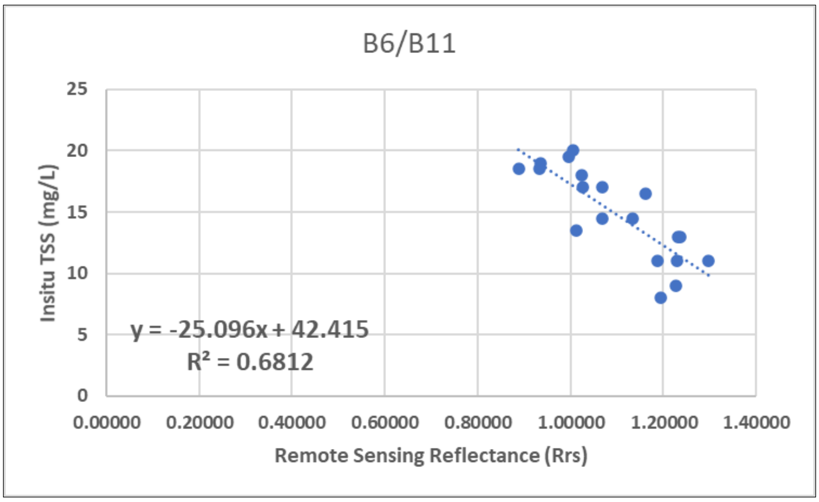

Figure 6. Graph of the Determination Coefficient (R^2) with the Highest Value in the Ayung Watershed Estuary

Table 7. Comparison of In-situ TSS Values with New Empirical TSS Values in the Ayung Watershed Estuary

Sample Code	In situ TSS (mg/L)	Empirical TSS (mg/L)
1D	19.5	17.4
1E	17	15.6
1K	19	18.9
1L	18.5	20.1
1S	16.5	13.3
1T	18	16.7
1U	18.5	19.0
1V	20	17.2
1W	14.5	15.6
1X	14.5	14.0
2B	13.5	17.0
2H	17	16.6
2I	9	11.6
2J	11	12.6
2K	8	12.4
2L	11	11.6
2M	13	11.4
2N	13	11.5
2O	11	9.9

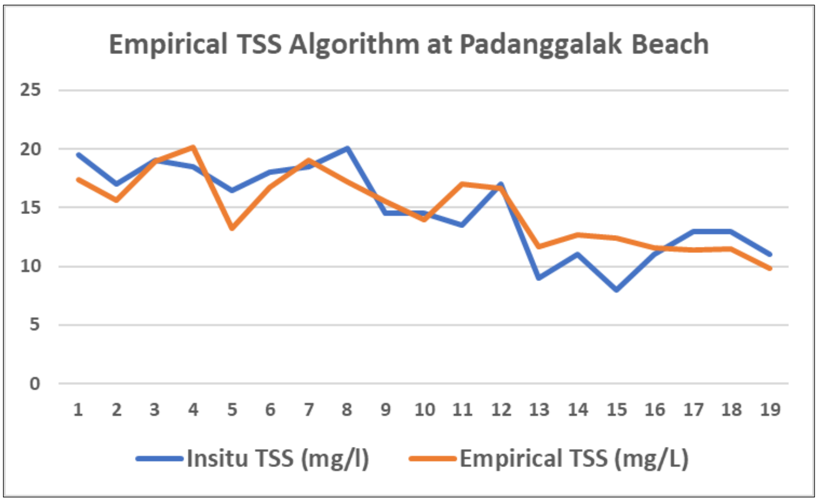

Figure 7. Comparison Chart of Insitu TSS Values with New Algorithm TSS Values

A new machine learning algorithm for estimating backscaterring (bbp*) using wavelengths in image channels ranging from (700 nm < λ < 800 nm) is solved analytically for waters dominated by suspended sediments. In this case, the use of Red Edge 1 (Band 5), Red Edge 2 (Band 6), and Red Edge 3 (Band 7) channels is used in the analysis [15]. Classification of Water Type III, namely brown water, shows the accuracy of using a wavelength of 740 nm (Band 6). This statement is in line with the results of the new algorithm modeling produced where in this study, the bands in the algorithm used were Band 6 and Band 11.

Visualization of the application of the new empirical TSS algorithm in the Ayung watershed estuary area (Padanggalak Beach) is shown in Figure 8.

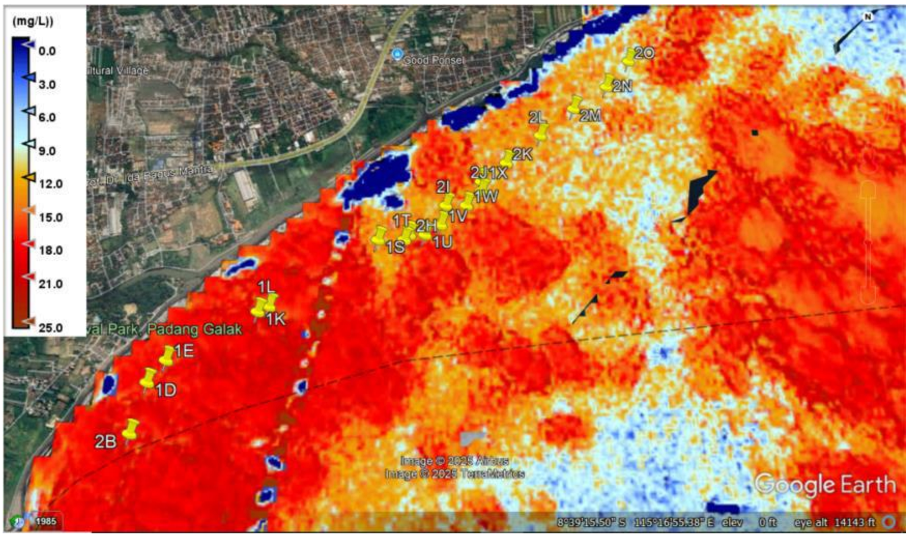

Figure 7. Application of New Empirical Algorithms in Ayung Watershed Estuary (Padanggalak Beach)

CONCLUSION

The form of the new algorithm equation produced along with its correlation level is **TSS = -25.096 x (B6/B11) + 42.415**, for TSS estimation at Padanggalak Beach. Based on the results of the analysis of the determination coefficient of the New Empirical TSS Algorithm with Insitu TSS, the R^2 result was 0.6812. This shows that the results of in situ data and the results of satellite image processing using the New Empirical Algorithm are considered to have a strong correlation relationship, which

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means that the TSS results from the empirical algorithm are quite in accordance with the TSS results in the field at the Ayung DAS Estuary (Padanggalak Beach). The suggestions that the author can provide regarding the improvement of this writing are to use more accurate and complete data to increase the level of accuracy of TSS estimation algorithm modeling, use more complex modeling methods, such as machine learning or deep learning, to increase the level of accuracy of TSS estimation algorithm modeling and develop TSS estimation algorithm modeling that can adapt to changes in environmental conditions and other factors that affect TSS.

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