Assessment of Inland Water Quality In Banjar Regency Using Remotely Sensed Satellite Image

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Abstract:- The main environmental issues in Banjar Regency Indonesia are the handling of residential wastewater and environmental degradation due to mining activities. Efforts to monitor and analyze water quality status with a large area and diverse land use require a lot of time and money. This research will help provide alternative solutions for predicting the quality of inland waters using remote sensing satellite image interpretation. The research was conducted to obtain the distribution pattern of water quality parameters such as Turbidity, TSS (Total Suspended Solid), organic CDOM (Colored Dissolved Organic Matter Absorption), and Chlorophyll-a (Chl-a). These four parameters are generally monitored through field sampling which is time-consuming and costly. Remote sensing provides the possibility to provide water quality information over a wide area and identify trends in changing water quality patterns through historical data. The research was conducted through the interpretation of Sentinel-2 satellite imagery and other sources such as Landsat and SRTM. Data were collected over the last 5 years and processed using the GEE (Google Earth Engine), ESA-SNAP (European Space Agency - Sentinel Application Platform), and QGIS applications. The interpretation results for current conditions are calibrated using field measurement data, then mapped to display patterns of water quality parameter conditions spatially and temporally. The last step is to perform spatial statistical analysis and the trend of changes in water quality using the GEODA application. The distribution of water quality parameter values shows various patterns for inland waters in Banjar Regency but tends to increase in locations close to residential and agricultural areas. All water quality parameters reviewed also show an increasing trend in the last 5 years according to the analysis period.

Keywords:- *Banjar Regency, Inland Water, Remote Sensing, Water Quality, Sentinel-2.*

I. INTRODUCTION

The condition of inland water quality, based on data from the Ministry of Environment and Forestry in 2019 stated that the quality of river water in Indonesia is deteriorating every year. Of the 98 rivers in Indonesia, 54 rivers are lightly polluted, 6 rivers are lightly polluted-moderately polluted, and 38 rivers are lightly polluted-severely polluted. This data is compared to 2018, from 97 rivers in Indonesia, 67 rivers are lightly polluted, 5 rivers are lightly polluted and 25 rivers are lightly polluted and heavily polluted [1].

Banjar Regency is one of the areas in South Kalimantan which has a large river, namely the Martapura River with an area of 453.88 km^2, and a length of 36,566 meters [2]. Banjar Regency itself has an area of 4,668.50 km^2 with a potential dry land area of 13,757 ha, tidal 32,252 ha, rainfed rice fields 13,446 ha, irrigation 5,497 ha, swamp or lebak 8,538 ha, and non-rice field agricultural land covering an area of 320,602 ha. In addition to strategic utilization in the agricultural sector, the development of residential areas is also a strategic issue of the Banjar Regency with one of the main problems, namely the handling of residential wastewater disposal, and environmental degradation due to mining activities [3]. The Environmental Service of South Kalimantan Province noted that there are dozens of companies operating in the Martapura sub-watershed area, three of which are coal mining companies. The existence of these dozens of companies has the potential to trigger pollution of the Martapura river which is the source of PDAM's raw water, transportation, agriculture and fisheries as well as other community economic activities. In addition to coal mining, dozens of companies operating along the Martapura sub-watershed are plantations, rubber, plywood, shrimp freezing, hotel and home industries. Pollution of the Martapura River is a priority for the handling of the South Kalimantan Provincial Government [4].

Efforts to monitor and analyze the status of water quality with a large area and quite diverse land uses require a large amount of time and money. This research will help provide alternative solutions for predicting the quality of inland waters using remote sensing satellite image interpretation. It is necessary to conduct research to obtain the distribution pattern of water quality on the parameters of turbidity (Turbidity), TSS (Total Suspended Solid), organic CDOM (Coloured Dissolved Organic Matter Absorption), and Chlorophyll-a (Chl-a). These four indicators are generally monitored through field sampling which is time-consuming and costly. Remote sensing provides the possibility to provide water quality information over a wide area, and identify trends in changing water quality patterns through historical data. Remote sensing applications in waters have been used as an effective alternative to monitor water quality. The color of the waters captured by remote sensing applications provides information about the optical

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properties of the waters [5]. Remote sensing technology which has experienced rapid development has an important role in supporting and covering the shortcomings of conventional sampling techniques.

The research is expected to assist efforts to monitor the quality of inland waters in Banjar Regency spatially and temporally by utilizing Sentinel-2A satellite imagery, Landsat, and SRTM. Sentinel-2A was chosen because it has a spatial resolution of 10 meters for the Green, Red, Blue, and NIR channels. Sentinel-2A acts as the main data used to determine the value and distribution of TSS, turbidity, CDOM, and Chl-a. Data were collected for the last 5 years, and processed using the Google Earth Engine, ESA-SNAP, and QGIS applications. The interpretation results for current conditions are calibrated using field measurement data, then mapped to display patterns of water quality conditions spatially and temporally. The last step is to perform a spatial statistical analysis of the trend in water quality changes using GEODA application.

II. METHOD

The research phase is divided into three research stages. The first stage is to perform water quality prediction calculations based on remote sensing satellite imagery data for turbidity, TSS, CDOM, and Chlorophyll-a in inland waters in the Banjar Regency area. The next stage is mapping the distribution pattern of inland water quality conditions in the Banjar Regency spatially from remote sensing satellite image data processing for turbidity, TSS, CDOM, and Chlorophyll-a. The last stage is to analyze the trend of changes in inland water quality conditions in Banjar Regency for the last 5 years for the parameters of turbidity, TSS, CDOM, and Chlorophyll-a.

The results of measurements and laboratory tests from the first research phase are not only used to determine the adsorption algorithm for water quality parameters but are also used for the calibration process. The satellite image obtained then goes through the stages of atmospheric, radiometric, and geometric correction before being processed by the adsorption algorithm for the prediction of water quality parameters. Before analyzing the interpretation of water quality, identification of the probability of the presence of inland waters carried a certain threshold. The research activity was continued by mapping the distribution pattern of inland water quality for the 4 specified parameters. After the spatial analysis was carried out, it was followed by a temporal analysis to determine the trend of changes in the condition of inland water quality in the Banjar Regency area.

The location of sampling and measurement points must represent the presence of rivers, lakes, and swamps in the Banjar Regency area. The location of sampling and measurement points in GCP (Ground Control Points) can be seen in Fig. 1.

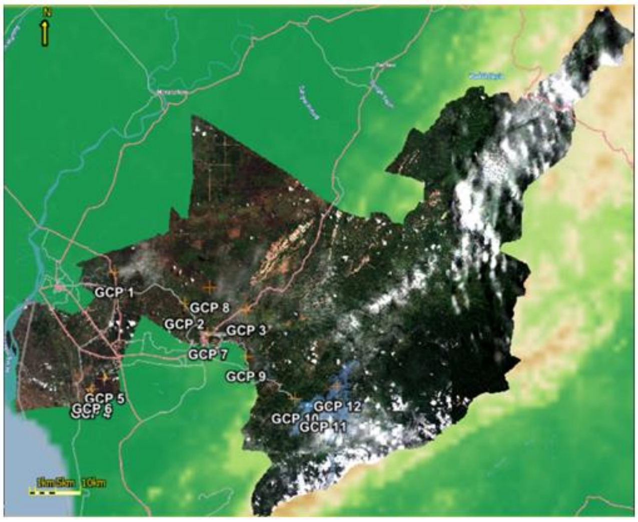

Fig 1:- Sampling Location

Analysis of water condition data for the last 5 years representing variations in time differences and the results of interpretation of water quality representing spatial variations were carried out by cluster analysis (CA). CA is a group of multivariate analyses whose main purpose is to classify objects based on the characteristics they have. CA is performed on data that has been standardized through Z-scale transformation (Z-scale). This transformation is used to avoid misclassification due to unit variations of each water quality parameter; In addition, through this standardization, it can increase the effect of parameters that have small variances and vice versa reducing the effect of parameters with large variances [6]. The CA results obtained are then mapped spatially using QGIS.

III. RESULTS AND DISCUSSION

A. Field Measurement and Laboratory Test Result

Table 1 shows the field measurement and laboratory water sample analysis results for several water quality parameters from sampling point locations

No.	GCP Point	X Coordinates	Y Coordinates	Field Measurement					Laboratory Test							
				Turbidity (NTU)	Conductivitys (µS/cm)	Salinitys (ppt)	TDS (ppm)	pH	TSS (mg/l)	DO (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	TOM (mg/l)	BOD (mg/l)	COD (mg/l)
1	River 1	**3°17'47.48"S**	**114°41'33.15"E**	28.30	0.220	0.1	117.00	7.05	24	6.1	<0.3	0.79	15.64	17.12	22.34
2	River 2	**3°21'10.34"S**	**114°48'57.55"E**	30.93	0.207	0.1	105.00	7.74	19	6.2	<0.3	0.19	14.97	17.12	21.39
3	River 3	**3°21'50.47"S**	**114°55'19.70"E**	160.00	0.318	0.1	168.00	7.60	77	6.3	<0.3	0.27	15.30	17.12	21.86
4	Pond 1	**3°30'38.75"S**	**114°39'1.70"E**	6.09	17.320	0.0	9.20	6.11	3	6.0	0.02	1.13	14.97	17.12	21.39
5	Pond 2	**3°29'4.51"S**	**114°40'29.05"E**	30.95	120.600	0.1	63.70	8.25	5	6.2	0.01	0.18	15.64	8.11	22.34
6	Pond 3	**3°30'9.25"S**	**114°39'9.99"E**	2.66	16.700	0.0	9.05	8.40	2	6.6	0.01	0.05	14.64	6.31	20.91
7	Swamp 1	**3°24'26.86"S**	**114°51'28.36"E**	13.04	144.600	0.1	55.00	7.27	12	6.3	<0.03	0.13	15.97	8.11	22.81
8	Swamp 2	**3°18'43.79"S**	**114°51'1.49"E**	4.27	30.400	0.1	16.70	4.94	8	6.2	0.01	0.08	18.30	18.02	26.14
9	Swamp 3	**3°26'42.61"S**	**114°54'30.02"E**	40.46	159.400	0.1	84.60	7.67	19	6.6	0.01	0.43	14.97	9.91	21.39
10	Lake 1	**3°31'15.29"S**	**115° 0'30.08"E**	6.66	161.900	0.1	85.90	8.12	2	6.0	0.01	0.17	14.64	16.22	20.91
11	Lake 2	**3°32'4.57"S**	**115° 3'41.35"E**	3.45	158.000	0.1	83.40	7.51	2	6.5	0.01	0.16	14.64	18.02	20.91
12	Lake 3	**3°29'54.02"S**	**115° 5'13.78"E**	3.77	156.100	0.1	82.50	7.58	3	6.7	0.01	2.70	14.64	12.61	20.91

Table 1:- Field and laboratory water quality on GCP points

Phosphate parameters at some points exceed the national water quality standard [7]. High levels of phosphate are generally caused by human or animal waste, and domestic activities. Excessive phosphate concentration will increase the growth of algae which results in reduced sunlight entering the water bodies [8]. BOD (Biological Oxygen Demand) parameter exceeds the national water quality standard for all measurement points. The higher the BOD level, the higher the activity of organisms to decompose organic matter. COD (Chemical Oxygen Demand) content showed a higher value than the national water quality standard at certain locations of the swamp. Similar to BOD, COD levels in water are associated with a decrease in dissolved oxygen content in the waters [9]. TSS (Total Suspended Solid) level at point river 3 also exceeded the national water quality standard limit. domestic and agricultural activities show a large influence on water quality conditions at the sampling points.

B. Satellite Imagery

The satellite image is taken from the Sentinel-2 satellite data with the help of the Google Earth Engine script. The image obtained through this script then goes through the stages of converting the coordinate reference system to UTM coordinates (WGS84/UTM Zone 50S). The image is also resampled to a resolution of 10 m. The images obtained are satellite images for Bands 1 to 12 which are averaged per year of observation. The image obtained is still divided into several images, so it must undergo a merging process. The merging process is carried out with the SNAP application through mosaicking. The combined satellite images are then processed and displayed in the SNAP application (Fig. 2). Observations were made from early 2018 to mid-September 2022.

Fig 2:- RGB image from SNAP

Based on the resulting image, the existing bands are then processed to obtain the values of NDWI (Normalized Difference Water Index), NDTI (Normalized Difference Turbidity Index), Turbidity, TSS (Total Suspended Solid), CDOM (Coloured Dissolved Organic Matter), and Chl-a (Chlorophyll-a).

C. River Water Quality Profile

The profile line in Fig. 3 is determined along the axis of the Martapura river with a total length of about 120 km. This profile is used to provide an overview of the pattern of changes in water quality parameters along the Martapura River from upstream to downstream.

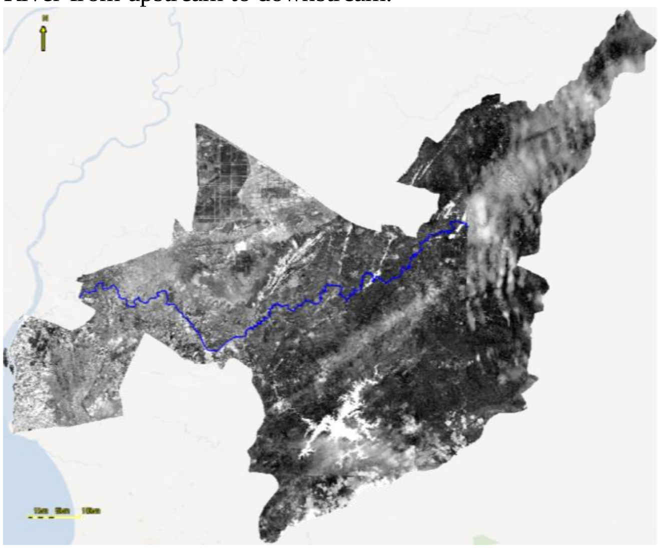

Fig 3:- River profile line

The results of satellite image processing along the river profile line (Fig. 4) showed a more varied pattern of fluctuations in the turbidity, TSS, and Chl-a parameters upstream. The CDOM parameter is very volatile along the Martapura river in 2018. CDOM shows an increase in locations close to residential and agricultural areas. In 2019 the pattern of changes that occur along the river profile is still fluctuating, especially for TSS and CDOM parameters. The turbidity parameter still has a higher tendency in the upstream area, and the CHL-a parameter is relatively not subject to various fluctuations. Conditions in 2020 compared to the previous year experienced an increase in TSS, CDOM, and Chl-a concentration.

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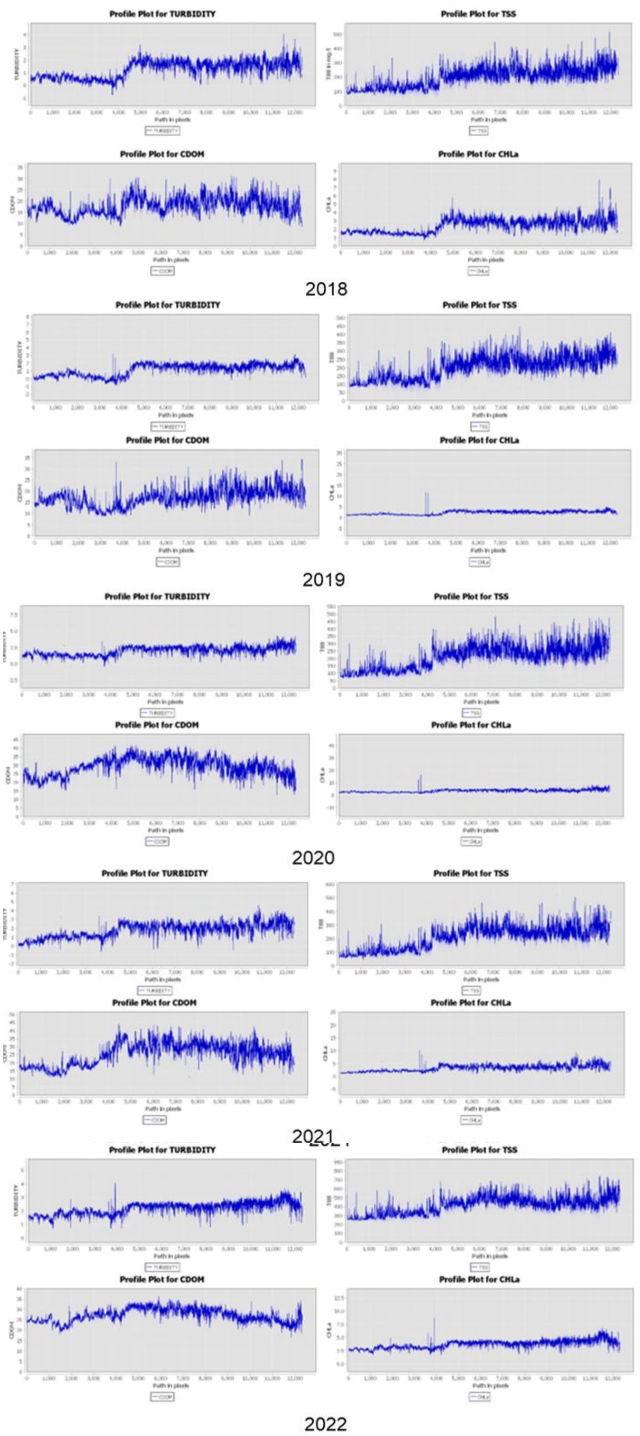

Fig 4:- Water quality profile for Martapura River

TSS and turbidity fluctuation patterns still showed high fluctuations, but still had higher values upstream than downstream. The CDOM pattern shows an increase in the middle of the river although it is quite varied. In the year 2021, there is an increase in Turbidity, TSS, and Chl-a and a decrease in the average value for CDOM. In general, the pattern of change for the turbidity and TSS parameters still shows variations in values, but tends to increase in the upstream part of the river. the number of CDOM parameters has increased in the middle of the river, especially in residential and agricultural areas. The CHL-a parameter did not show significant variation, but there was an increase in several locations in the upstream and middle part of the river near the downstream. Conditions in 2022 have a different pattern compared to 2021. At some points, there are some increases in the concentration of turbidity, TSS, and CDOM, especially in the middle of the longitudinal profile of the Martapura river. Some spikes in water quality parameters are found, especially in areas adjacent to residential, agricultural, and industrial areas.

D. Lake Water Quality Profile

Fig. 5 shows the location of lakes in Banjar Regency area. the lake has an area of 97.3 km^2. The water quality distribution pattern in the lake is determined through the results of cluster analysis which divides the lake area into 9 clusters. Histogram data for each cluster was obtained through analysis using the GEODA application based on the distribution map of each water quality parameter.

The lake organic concentration of CDOM in 2018 was higher at the top of the cluster than the others. However, the highest amount of data occurred in the lower cluster at the sides of the lake. The same pattern also occurred in 2019, but there was a decrease in the concentration of CDOM. The distribution of the highest concentration is still dominant in the upper and lower clusters of the reservoir. Conditions in 2019 described a decrease in the value of the CDOM concentration, especially in the right cluster part of the lake. This condition still occurred until 2021, but in 2022 the concentration of CDOM increased in almost all of the lake clusters (Fig. 6).

The distribution pattern of Chl-a in the lake shows a fairly uniform pattern, although the highest number of Chl-a occurs more in the upper cluster. This condition continued until the end of the observation year. Chl-a concentrations decreased in 2020 and 2021 compared to 2018 and 2019 but increased again in 2022 (Fig. 7).

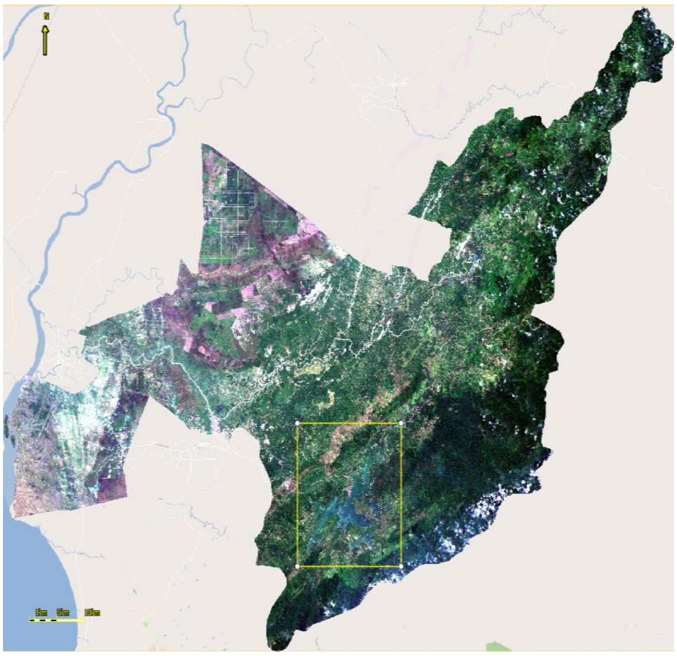

Fig 5:- Location of the lake in Banjar Regency

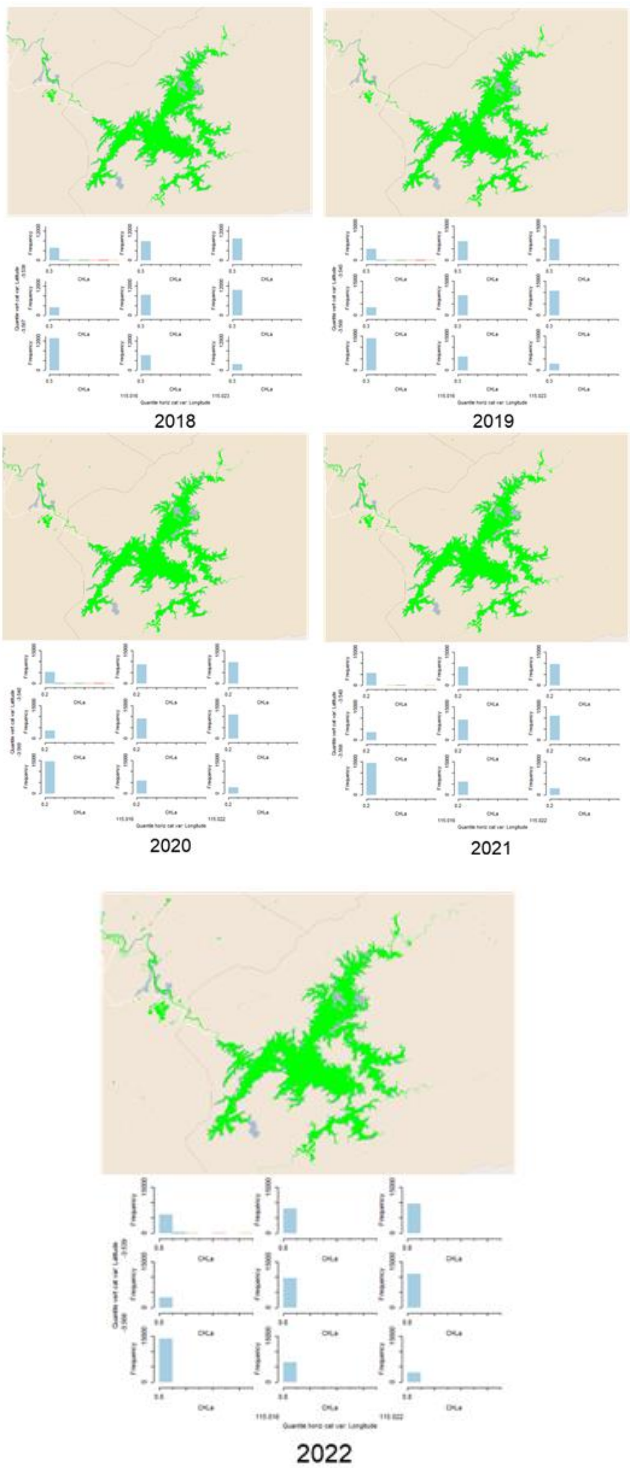

Fig 6:- Distribution of Chl-a in the lake

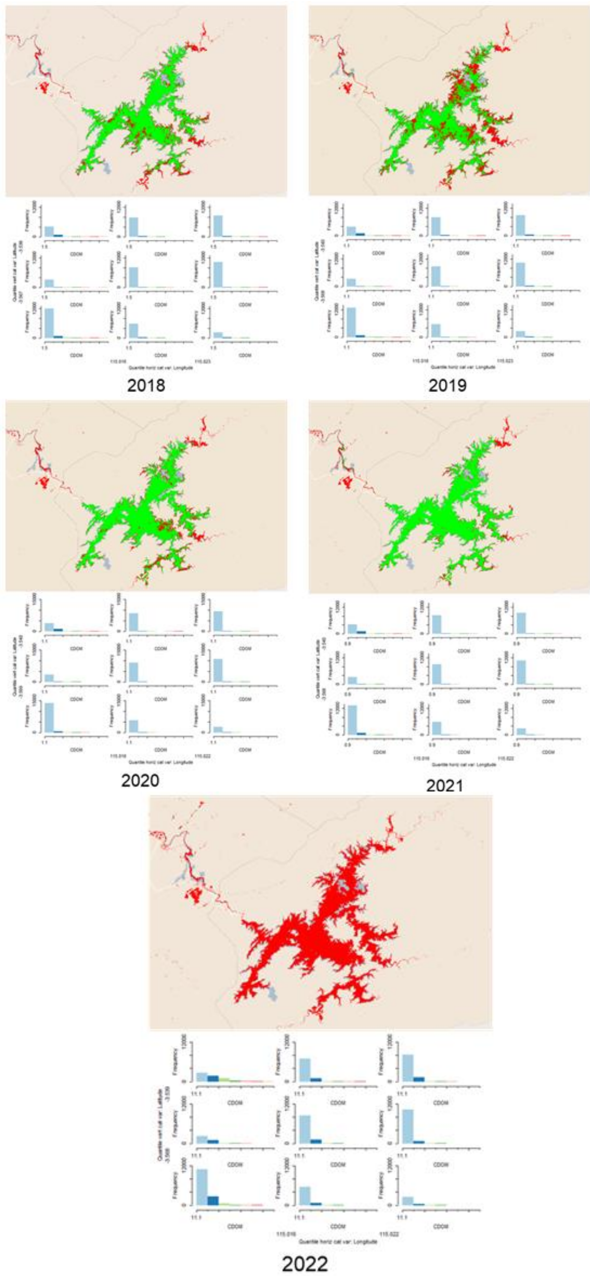

Fig 7:- Distribution of CDOM in the lake

Water quality data from satellite imagery at observation points are then averaged based on the year of observation. This value was analyzed using linear regression to obtain the trend of changes in water quality conditions in the Banjar Regency area. The regression results show that all water quality parameters tend to increase in concentration following the linear equation slope of 0.2664 and an intercept of - 537.42 for the turbidity parameter. The TSS parameter has a linear equation with a slope of 46,847 and an intercept of -94458. The CDOM parameter follows a linear equation with a slope of 1.8112 and an intercept of -3642.7 and Chl-a with a slope of 0.3813 and an intercept value of -768.07. This shows that the condition of water quality in Banjar Regency is experiencing a declining trend in quality in the coming year.

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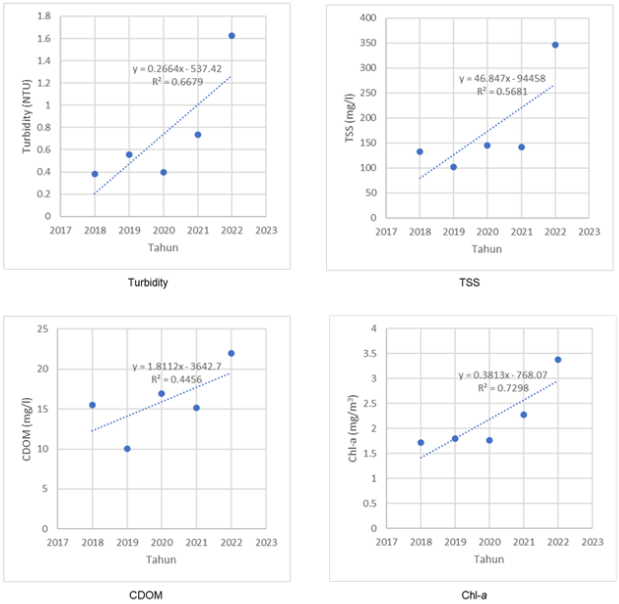

Fig 8:- Water quality trendline

IV. CONCLUSION

The distribution of water quality parameter values shows a diverse pattern for inland waters in Banjar Regency but tends to increase in locations close to the settlements and agriculture area. In general, all water quality parameters showed an increasing trend. This result gives the possibility of a water quality decrease in Banjar Regency.

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