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Estimation of Pb and Total Suspended Solid (TSS) Concentration based on Remote Sensing Data

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Abstract

Research has been carried out on the comparison of the concentration of Pb and Total Suspended Solid (TSS) of laboratory test results with Sentinel-2A satellite image data recorded on August 25, 2021 at the Suwung estuary dam, Denpasar city. The method used to compare the 2 measurement results is through testing by paired sample correlation and the graph. The result from the measurement show that the TSS value between Sentine-2A and laboratory has a fairly close value but the Pb value between Sentinel-2A and the laboratory have a much differences. The differences of the value between Sentinel-2A images and laboratory data can be caused by differences in the image recording time and field data collection time. This can result in changes or dynamics of water conditions that result in changes in the value and distribution Pb and then the radiometric influence of differences in Pb values on images and laboratory data can be caused by radiometric influences or interference with wave propagation in the air.

Introduction

Water is used as a process of growth and development of all living things, both in small and enormous quantities depending on the needs of life. Humans use water for daily life in sufficient quantity and quality according to their needs [1]. The Suwung Estuary dam (reservoir) located in Kepaon village, South Denpasar sub-district, Denpasar city is a water reservoir from the Badung tukad which is equipped with a rubber weir as a spillway and a radial door. The reservoir with an area of 35 ha and a depth of ± 3.7 m is used for raw water supply handled by the Denpasar raw water supply project. This water is processed to serve the needs of clean water in the Denpasar and South Badung areas. Given the vital role

insupplying water, the water quality of this dam is important to be known because its condition is threatened with contamination by waste disposal from various urban activities.

The biggest activity carried out by humans in the Suwung Estuary dam area is to use this area as a final disposal site which is located close to the mangrove area. The water pollution caused is not only detrimental to the people living in the Suwung Estuary dam area, but is like water flowing from upstream to downstream, which means it also brings negative impacts to other communities [2].

Water quality evaluation is generally carried out using the field measurement method in the form of collecting water samples for testing and analysis in the laboratory. This method can only show the value of water quality at the sample points tested at the time of sampling, but cannot properly explain the distribution and spatial pattern of water quality distribution in all parts of the water body. A more effective alternative method that can be used to estimate the spatial distribution of water quality is to apply remote sensing satellite technology. Remote sensing satellites record the characteristics of the reflection and emission of various objects on the earth's surface, including bodies of water to determine the material contained in the water. The method commonly used in the study of water quality is the creation of a regression model from the results of the relationship between the reflection value or spectral characteristics of water recorded on remote sensing images with the results of measurements of field water quality parameters (in situ). The model is then re-applied to the remote sensing image, so that it is able to quantitatively map the water quality parameter values in all parts of the water body [3].

The physical parameter that can be used for assessment or calculation and analysis of water quality is the concentration of total suspended solids or Total Suspended Solid (TSS). One technique for calculating TSS is with the help of remote sensing satellite data which is supported by direct measurements in the field. Remote sensing data can be used to see the level of water brightness and other water quality parameters [4].

From the description above, researchers are interested in conducting research using remote sensing technology to determine the physical parameters of water quality, namely the spatial distribution of TSS concentrations and the potential for heavy metals contained in the Suwung Estuary dam. The value of TSS concentration and potential heavy metals obtained from the results of remote sensing data processing will be compared with those obtained from the laboratory (in situ). Considering that the study area is not too wide and to get more accurate results, the remote sensing data used is Sentinel-2A satellite imagery data. The spatial resolution of the Sentinel-2A image is 10 m and the temporal resolution is 5 days.

Theoretical basis

Water quality

Water is one of the most important needs for the survival of humans and other living things. Hence, the water that organisms depend on must meet the requirements in terms of quality and quantity [5]. Quality is a quality characteristic required for certain uses of various water sources. Water quality criteria are a standard basis regarding the quality requirements of water that can be utilized. Water quality standard is a regulation prepared by a country or a region concerned. According to Acehpedia [6], water quality can be determined by performing certain tests on the water. The tests carried out are chemical, physical, biological, or appearance

tests (smell and color). Water quality management is an effort to maintain water so that the desired water quality is achieved according to its designation to ensure that water conditions remain in their natural condition. Some metals that are classified as heavy metals, such as iron (Fe) or lead (Pb) are often found and pollute the waters. The presence of heavy metals like this can often interfere with the life of zooplankton and phytoplankton in water. Government Regulation number 82 of 2001 has determined water quality criteria that meet the quantity of class I quality standards including for suspended residue or Total Suspended Solid and concentration of Lead (Pb) as shown in Table 1.

Table 1. Water Quality Parameters (PP no. 82 of 2001).

No	Parameter	Unit	Class I Quality Standard
1	Suspended residue or total suspended solid	mg/l	50
2	Lead Concentration	mg/l	0.03

Lead (Pb)

Lead (Pb) or in everyday life better known as tin, in scientific language it is called Plumbum, is widely used in modern industry as a material for making water pipes that are resistant to corrosion. Pb pigments are used in the manufacture of paints, batteries, and gasoline fuel mixtures. In addition, lead is also used in the cable industry, plating, pesticides, as an anti-explosion agent in gasoline, as a constituent of solder or solder, as a formulation for connecting pipes to allow contact between household water and Pb [7]. Lead is found in all-natural substances and almost all humans come into contact with this invisible heavy metal in many ways, either where they live or where they work. The distribution of lead in the environment is wider than that of other toxic metals. Usually Pb levels in soil range from 5 – 25 mg/kg, in groundwater 1 – 60 g/l and in air less than 1 g/m3, but can be much higher in certain workplaces and in areas with heavy traffic [8].

Sentinel-2A Satellite Image

Sentinel-2A is a remote sensing observation satellite with a European-made 8 multispectral passive sensor which has 13 bands. Sentinel-2A consists of 4 bands of 10 m resolution, 6 bands of 20 m resolution, and 3 bands of 60 m spatial resolution with a sweep area of 290 km (https://inderaja-catalog.lapan.go.id). The relatively high spatial resolution and wide spectrum coverage is a big step forward compared to other multispectrals. Sentinel-2A image is a product that has advantages in radiometric bits, so it has a much better image quality than the previous generation Sentinel image. With Sthe 10 m spatial resolution specification is helpful in land monitoring. Accurate resolution of bands and wavelengths is important as errors of 1 nm can induce errors in reflection [9]. The specifications for the Sentinel-2A image band are shown in Table 2.

Research methods

This research takes place in the village of Kepaon, South Denpasar sub-district, Denpasar city which is astronomically located at 8°43'26"-8°44'04" South Latitude and 115°11'16"-115°11'22" east longitude.The data used is Sentinel-2A satellite image data recorded on August 25, 2021 which was downloaded from the sitehttp://eartheexplorer.usgs.gov/and data on the

concentration of TSS and heavy metal Pb because of measurements from the laboratory. The method used in this study is explained by the flow chart presented in Figure 1.

Table 2. Band specifications on the Sentinel-2A image.[10]

Sentinel-2A Band	***Central Wavelength*(μm)**	***Resolution*(m)**
*band*1 (Coastal aerosol)	0.443	60
*band*2 (Blue)	0.490	10
*band*3 (Green)	0.560	10
*band*4 (red)	0.665	10
*band*5 (Vegetation Red Edge)	0.705	10
*band*6 (Vegetation Red Edge)	0.740	20
*band*7 (Vegetation Red Edge)	0.783	20
*band*8 (NIR)	0.842	10
*band*8A (Vegetation Red Edge)	0.865	20
*band*9 (Water vapor)	0.945	60
*band*10 (SWIR-Cirrus)	1.375	60
*band*11 (SWIR)	1.610	20
*band*12-SWIR	2.190	20

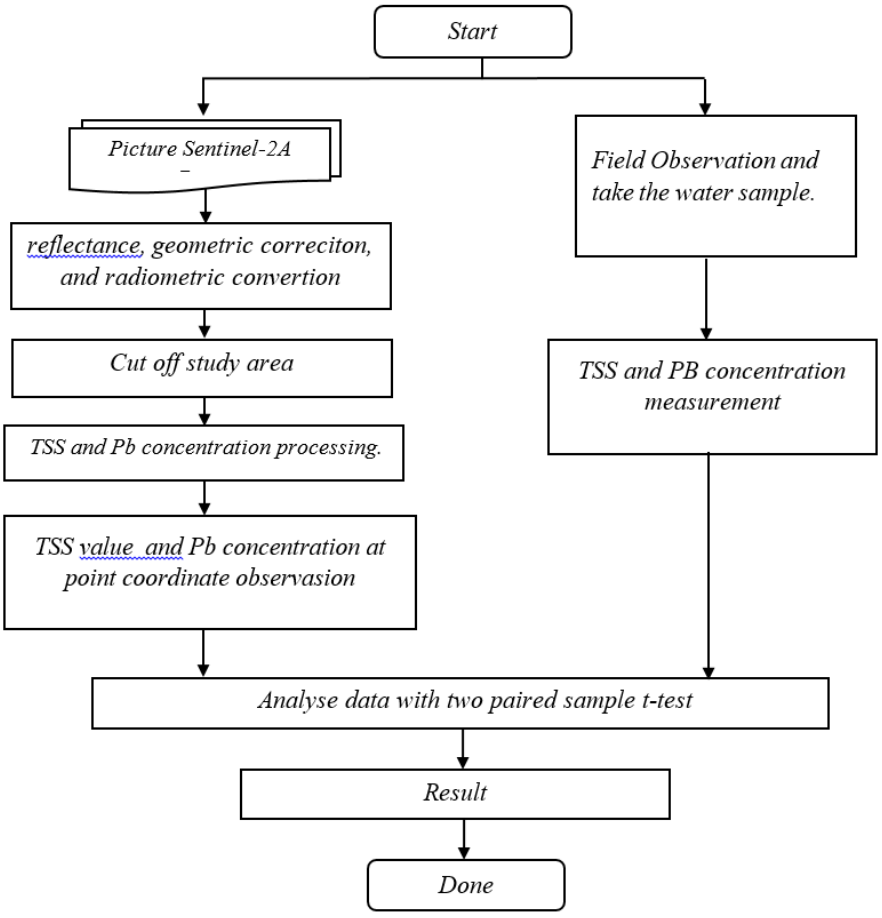

Figure 1. Research flow chart

Algorithm TSS to estimate the result of TSS shown in Equation (1)

$$TSS\left(\frac{mg}{l}\right) = 31.42\frac{(Log\,(R_{RS}\ Blue))}{(Log\,(R_{RS}\ Red))} - 12.719 \quad (1)$$

Measurement of Pb levels concentrations in Sentinel-2A images was carried out on the pixel values of the visible wavelength spectral reflectance band (spectrum). This is because the measurements made with the Visible Spectrophotometer are also at visible wavelengths, namely at a wavelength of 400-600 nm. To see the strength of the relationship and the validity of the TSS data and Pb concentration derived from the Sentinel-2A image with laboratory measurement data, a paired sample t test was performed. As the independent variable (x) is TSS and Pb concentration measured on the Sentinel-2A image, while the dependent variable (y) is TSS and Pb concentration from laboratory measurements. The analysis was carried out by describing and comparing the results from the TSS model and the Pb concentration obtained from the Sentinel-2A image data with the results from laboratory data.

Results and Discussion

Before calculating the TSS estimation and determining the potential distribution of Pb, the Sentinel-2A image was processed first, namely geometric and radiometric correction processes. Geometric correction aims to improve the position of pixels so that they have the same coordinates or according to geographic coordinates and radiometric correction gives a range of values that are more varied and color changes in the image. The results of the distribution of TSS in dam water on the Sentinel-2A shown in figure 2.

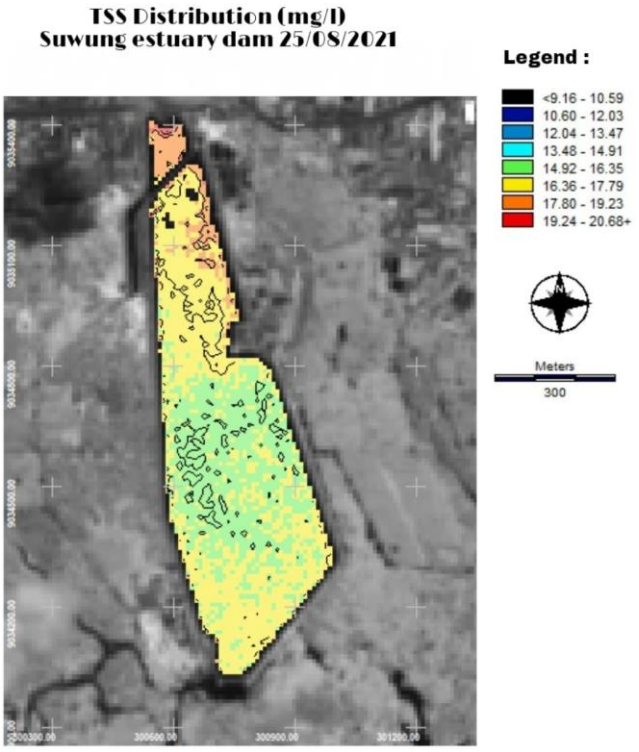

Figure 2. The results of the distribution of TSS in DAM water on the Sentinel-2A image

The TSS algorithm is intended to estimate and interpret the spatial distribution of dam water TSS on Sentinel-2A images..The comparison of TSS concentrations between laboratory data and Sentinel-2A data at 30 TP is presented in a graph as shown in Figure 3.

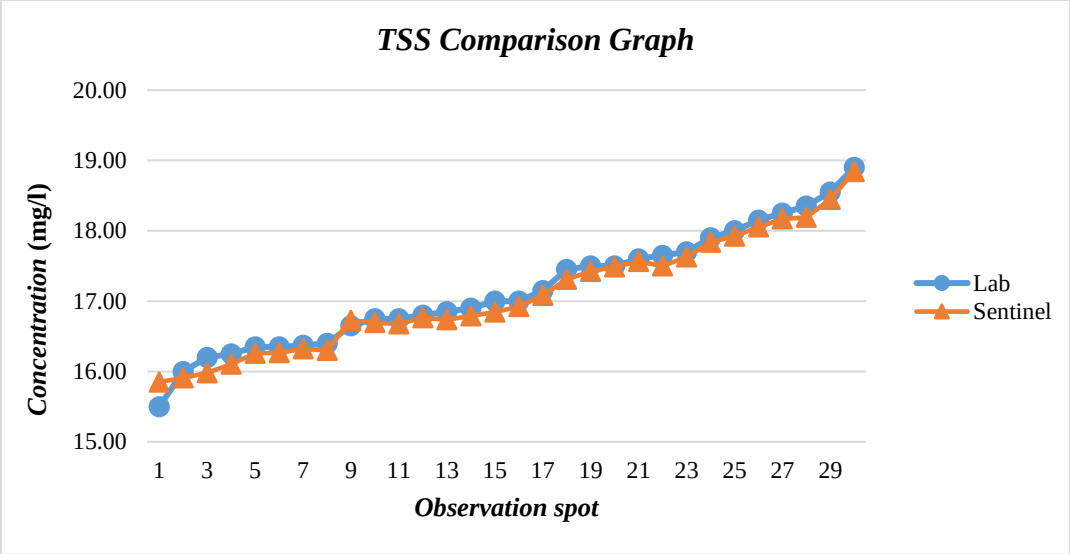

Figure 3. Comparison of TSS Concentration

The estimation of the potential distribution of Pb on the water surface of the Suwung Estuary dam was measured in the laboratory using a visible spectrophotometer with a wavelength of 510 nm and using Sentinel-2A satellite image data, namely band 3. The following is the result of processing the Sentinel-2A image for Pb which is presented in Pb concentration distribution map form as shown in Figure 4. And for The comparison of Pb concentrations between laboratory data and Sentinel-2A data at 30 TP is presented in a graph as shown in Figure 5.

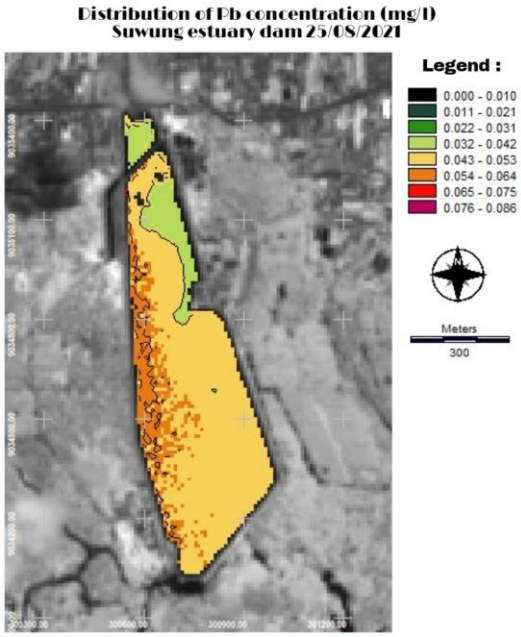

Figure 4. The results of the distribution of Pb in dam water on the Sentinel-2A image.

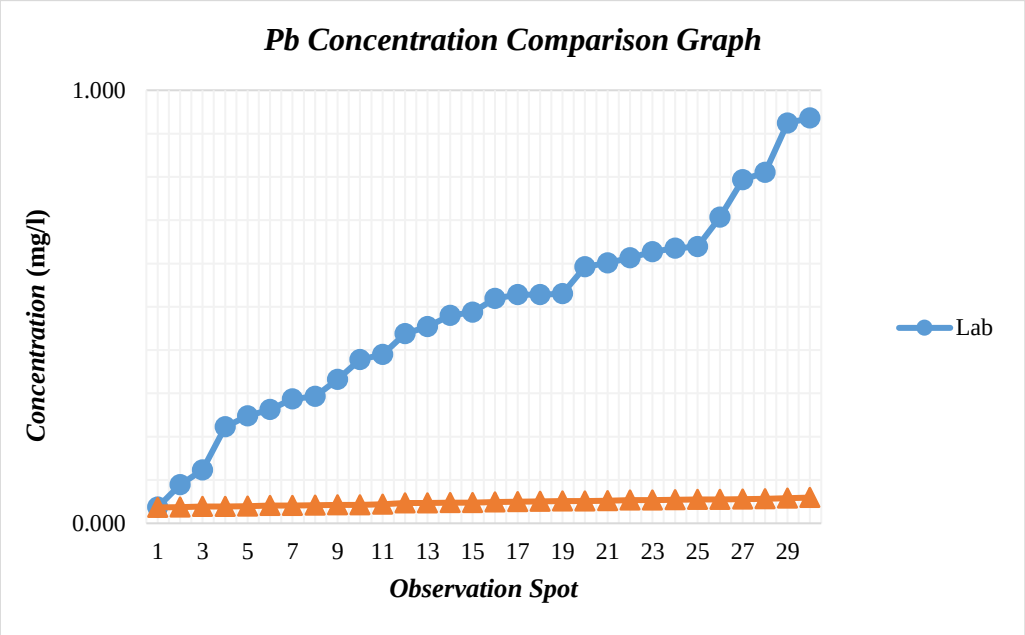

Figure 5. Comparison of Pb concentration

Discussion

Based on the data from the measurement of the TSS value of the dam water on the Sentinel-2A image and laboratory measurements, a graph of the TSS concentration between laboratory data and Sentinel-2A image data is obtained in Figure 3. It is known that the TSS value of each observation point does not always increase linearly, but also decreases. at several points of observation. The graph shows that the TSS value at 30 observation points has the highest value at the 30th point. The concentration of TSS in laboratory data has increased at every point, with the lowest concentration being at the 1st observation point with a value of 15.50 mg/l. The highest concentration was at point 30 with a value of 18.90 mg/l. In Sentinel-2A data, the lowest TSS concentration is at point 1 with a value of 15.85 mg/l and the highest concentration is at point 30 with a value of 18.84 mg/l.

Based on the Pb data on Sentinel-2A images and laboratory measurements, the comparison between Sentinel-2A data and laboratory data can be seen in Figure 5. It is known that laboratory data uses a wavelength of 510 nm, the lowest Pb concentration value is 0.037 nm, and the highest value is 0.936 nm. Sentinel-2A data uses a wavelength of 560 nm and has the lowest value of 0.0367 nm at the 1st point and the highest value of 0.0594 nm at the 30th point. Human activities and waste disposal around the research site could cause this.

The results of the paired samples statistics test on the TSS show that the average value of sentinel-2A is 17.0873 and the average value of the laboratory is 17.1590. From the average value, it can be seen that the TSS value based on sentinel-2A and laboratory results is almost the same. The paired samples correlations test results show that the correlation value is 0.994 and the significance value is 0.000, where the sig value is > 0.00. As a result, the TSS results between Sentinel-2A and the laboratory have a significant relationship.

The results of paired samples statistics show that the average Pb value of Sentinel-2A is 0.04800 and the average Pb of the laboratory is 0.48347. Thus, the average value of laboratory Pb is greater than sentinel-2A Pb. The results of Paired Samples Correlations show that the correlation value is 0.976 and the significance value is 0.000. This means that there is a relationship between Sentinel-2A Pb and laboratory Pb.

Based on graph that shown in Figure 3, the values of TSS from Sentinel-2A data and laboratory data has a fairly close value but for the values of Pb, there are differences between Sentinel-2A images and laboratory data shown in figure 5. This can be caused by differences in image recording time and field data collection time [11]. Image recording time is on August 25, 2021 at 20:32:06 while the time for field data collection is from 14.30.00-15.30 WITA. It can be seen the time lapse in field data collection. This can result in changes or dynamics of water conditions that result in changes in the value and distribution of Pb and subsequently the radiometric influence of differences in Pb values on images and laboratory data can be caused by radiometric influences or interference with wave propagation in the air [12].

Conclusion

The concentration of TSS laboratory results has increased at every point. With the lowest concentration at the 1st observation point with a value of 15.50mg/l and the highest concentration at the 30th point with a value of 18.90mg/l. And the Pb concentration has the lowest value with a value of 0.037 nm at the 1st point and the highest value of 0.936nm at the 30th point. In the Sentinel-2A data, the lowest TSS concentration is at point 1 with a value of 15.85 mg/l and the highest concentration is at point 30 with a value of 18.84 mg/l. At sentinel-2A the Pb concentration had the lowest value of 0.0367 nm at the 1st point and the highest value of 0.0594 nm at the 30th point. And the comparison of the concentrations of Pb and TSS laboratory test results with data from the Sentinel-2A satellite image based on the results of the paired sample correlation test that has been carried out on the results of TSS and Pb obtained. The result from the measurement show that the TSS value between Sentine-2A and laboratory has a fairly close value but the Pb value between Sentinel-2A and the laboratory have a much differences. Differences in the value between Sentinel-2A images and laboratory data can be caused by differences in the image recording time and field data collection time. This can result in changes or dynamics of water conditions that result in changes in the value and distribution of Pb and then the radiometric influence of differences in Pb values on images and laboratory data can be caused by radiometric influences or interference with wave propagation in the air and the distribution of TSS and Pb concentrations in the Suwung Estuary dam is uneven.

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