JOURNAL OF APPLIED GEOSPATIAL INFORMATION

Vol 6 No 2 2022

http://jurnal.polibatam.ac.id/index.php/JAGI
ISSN Online: 2579-3608

TSS Analysis (Total Suspended Soil) Using GEE (Google Earth Engine) Cloud Technology in Belawan Waters

Mardame Pangihutan Sinaga[1]*,Jono Barita Sianipar[2] Ady Frenly Simanullang[3], Goldberd Harmuda Duva Sinaga[4], Ewin Handoco S[5], Welmar Olfan Basten Barat[6].

[1,3,4,5,6] University of HKBP Nommensen Pematangsiantar / Water Resource Management / research / Sangnawaluh Street #4, Siopat Suhu Village, Siantar Timur District. Province of North Sumatera. Area Code: 21139. [2] Lab Data Spasial.

Corresponding Author e-mail*: m.pangihutan@gmail.com

Received: June 20, 2022
Accepted: August 16, 2022
Published: August 16 , 2022

Abstract

The TSS research using GEE Cloud Technology in Belawan Waters was carried out from January to May 2021. The analysis was carried out using the Sentinel-2 Satellite. TSS results obtained that the amount is 0,011010879-53,74369064 mg/liter. The content of TSS is spread evenly around the outskirts of Belawan Waters to the Middle of Belawan Waters and has passed the quality standard limit according to the Minister of Environment of Republic Indonesia which means the Harbour area is polluted and improper for drinking water as well as for fish cultivation. The result has been season influence can determine the direction of TSS distribution pattern, both tidal factors and weather conditions such as rain and dry season. Tide effect on TSS distribution pattern in Belawan Waters causes the TSS value at high tide to be higher than at low tide. Sentinel-2 TOA Reflectance Data imagery can be used to map the TSS distribution pattern in the Belawan Waters area.

Keywords: TSS, Sentinel-2 Satellite, Belawan Waters.

1. Introduction

Sub Introduction

Belawan river waters are open waters that are directly related to the Deli River watershed. Deli river is one of the rivers that divide the city of Medan to the North and empties into the Waters of Belawan. The Belawan area is an international standard port area that is full of industry and settlements as well as other public facilities. Currently, there are around 35 industries such as CPO (Crude Palm Oil) storage, fertilizer industry, and cement industry in Belawan. One of the causes of damage to ecosystems is heavy metals, one of which is heavy metal Pb which can cause poisoning, death, and damage to living tissue.

Total Suspended Soil (TSS) are suspended substances or materials with a maximum size of 2 m consisting of mud, fine sand, and other particulate matter such as biotic or abiotic components. These components come from land, sea, and atmosphere that are carried to water bodies through various factors such as wind, rainfall, waves, currents, and tides that can affect TSS concentrations in natural waters (Effendi, 2003). Waters with a high TSS value will affect the brightness so that light penetration is inhibited into the water and results in disruption of photosynthesis and the survival of marine life and for a long period of time will result in siltation or sedimentation..

The concentration of TSS can also be influenced by rainfall where rainwater is a medium for transportation of pollutants from the surface such as bacteria and other microorganisms. A high level of rainfall will cause a higher level of TSS concentration compared to a low level of rainfall (Bae, 2013).

Remote sensing technology is one of the sources of information in collecting marine data effectively and efficiently and remote sensing covers a wide area of study, the accuracy is relatively high, and the process requires less time and costs and is shorter than field surveys. There are several products from satellite imagery that provide information about an image of water including several types of satellite imagery, namely Landsat, SPOT, Quick Bird, Worldview-2, and Sentinel images. The satellite image used to determine the distribution and concentration level of TSS in Belawan Waters is Sentinel-2 with a spatial resolution of 10 meters.

The purpose of this study was to analyze the content of TSS (Total Suspended Soil) using sentinel-2 in the Belawan Waters and its surrounding at the time before and after rainfall, to expand rainfall to TSS the wide waters, the phenomenon of TSS descent around the estuary and need to study discharge. Rainfall on TSS, which is basic information for other researchers in further research to determine the effect of TSS in living tissue, as a reference source in the management of the Belawan Harbor Waters area which is more environmentally sound, and as information for the local government and local residents which in the Belawan Harbor Waters.residents which in the Belawan Harbor Waters.

2. Methodology

This research was conducted in January-May 2021. The time period includes data collection, data analysis, and processing, as well as the preparation around Belawan Waters, North Sumatera Province. As shown in the location map in Figure 1, data processing and analysis were carried out at the GIS Laboratory at the Study Program of Waters Resources Management

Methods and Tools

Data

Sentinel-2 satellite image data source obtained from NASA downloaded via the website: https://earthengine.google.com/.

Equipment

The tools and materials used in this study are tabulated in Table 1.

Table 1. Tools and Materials used during data processing.

Materials	Function
TSS in situ data	Secondary Data (9 stations)
Sentinel-2 . Satellite Image	Primery Data
Rainfall	Secondary Data
Data Analysis Tool	**Function**
Laptop	Data Analysis
Ms. Excel 2016	Data processing and calculation
ArcGis 10.5	Map Visualizaton

Methods

Sentinel 2 images processing in the analysis of total suspended solids TSS using GEE (Google Earth Engine) Cloud is divided into several processes, namely taking the Collection Snippet, Resampling (Geometric Correction), masking (Separating land and sea), TSS calculation based on the algorithm from (Liu *et al*., 2017), then export maps to Google Drive

1. Take *Collection Snippets*

Collection snippet retrieval is the initial stage in image processing. The Collection snippet process starts with: ee.ImageCollection("COPERNICUS/S2_SR") into the script in : https://code.earthengine.google.com/.

2. *Filtering*

Filltering the data to be obtained. There are 2 ways to filte on the google earth engine, namely:

a. Date
b. Observation

To obtain data, the dates and observations to be studied must be entered, namely:

```
.filterDate('2021-01-01', '2021-01-31')
.filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 30))
.map(maskS2clouds)
.filter(ee.Filter.bounds(roi));
```

3. Retrieval of the selected data and the mean of the set:

```
var tss = clipped.expression(
    "(ndwi > 0.1) ? 2950 * pow(VNIR,1.357)"+
    ": 0",{
      'ndwi' : ndwi,
      'VNIR' : image.select('B7')
}).rename('tss');
```

4. Image Analysis

Image analysis to determine TSS using an algorithm developed (Liu, dkk., 2017) with modell:

$$C_{SPM} = 2950\ x\ B7^{1.357}$$

CSPM is suspended in particular matter, while the exponent value is 2950 which is the coefficient and B7 is the Band 7 channel in the Sentinel-2 image. Band 7 was used because the MAPE (mean absolute percentage error) value was 16,58%, RMSE (Root Mean Square Error) was 16,50% mg/l, and F (test score) was better than the scores in the other bands.

5. *Masking*

Masking can be said to be a technique of separating land and sea. Masking is done as an effort to improve image quality in terms of visuals and available information. The masking results are expected to reduce the error of intercepting information in a deeper analysis. Formula value in masking (land and sea separator) is:

- .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 30))
  .map(maskS2clouds)
  .filter(ee.Filter.bounds(roi));
- var tssMasked = tss.updateMask(tss.gt(0));
  Map.addLayer(tssMasked, vizTSS, 'TSS masked');
  Map.add(colorBar)

6. Export Maps to Google Drive

Transferring data results in the form of maps by exporting maps to Google Drive. Then, the exported map (*.tiff) is transferred to ArcGIS to view the resulting TSS data.

Results and Discussion

Results

Tide

The tidal phenomenon is a process that occurs in the sea continuously. This natural process occurs due to the gravitational force of the sun, moon, and celestial bodies that attract each other so that the parts of the earth that are close to celestial bodies will experience tides, while in other parts of the earth there will be receding. Salinity, temperature, pH, DO, and brightness.

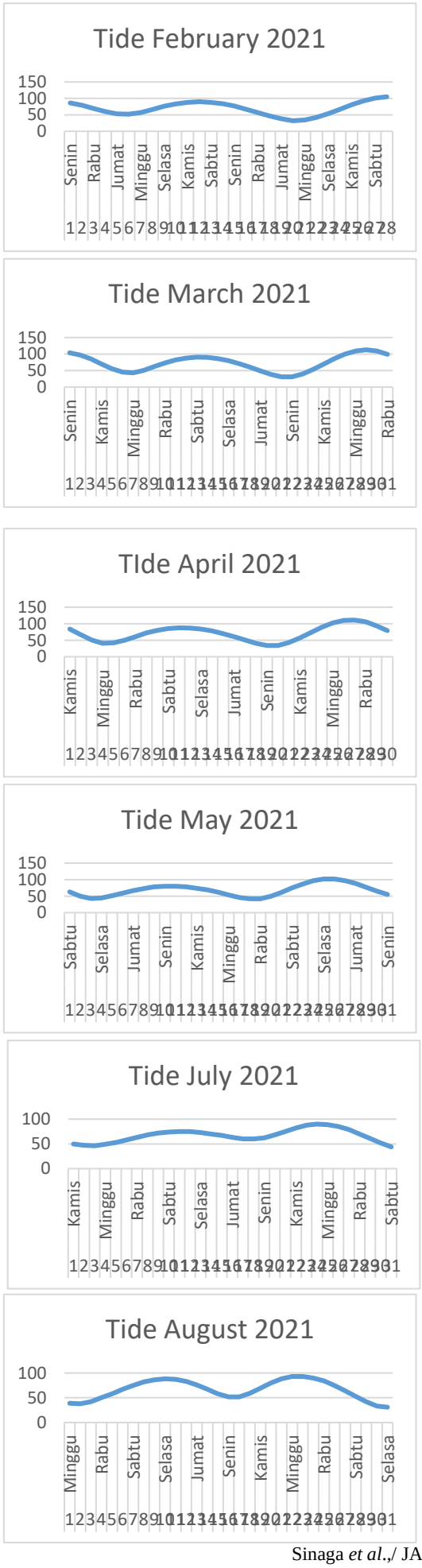

Figure 1. Real Time Tide Prediction in February, March, April, May, July, August, October, November and December 2021.

Rainfall

Precipitation is water released from clouds such as rain, snow, or hail. Precipitation begins after water vapor, which has condensed in the atmosphere becomes too heavy to remain in the atmospheric air currents and falls.

The stages of rain process:

1. Evaporation

Evaporation is the process of changing liquid water into gaseous water (evaporation). This allows the gas to rise above the Earth's atmosphere. The higher the sun's heat, the more amount of water that becomes water vapor and rises to the earth's atmosphere.

2. Transpiration

The other stage is the evaporation of water. Evaporation of water does not only occur in the soil but also takes place in the tissues of living things. Basically, the working principle of transpiration with evaporation is almost the same. Both turn water into water vapor which rises to the top of the atmosphere.

Transpiration is the process of evaporation in plants when they breathe. However, the amount of water that becomes vapor through transpiration is

generally much less than the amount of water vapor produced by evaporation.

3. Condensation.

Furthermore, water vapor undergoes condensation or condensation in the form of ice particles. Changes in form occur due to the influence of very low air temperature at that altitude.

The ice particles are then formed into saturated clouds which will then be the beginning of the process of rain.

4. Precipitation (Rain)

This stage is the stage of the occurrence of rain. The reason is, that at this stage the saturated clouds containing water droplets in the atmosphere get colder. This makes the clouds heavier until finally the water droplets they contain fall to the earth's surface.

The fall of water droplets from the atmosphere to the earth's surface is called rain. If the ambient temperature is less than 0 0C, snow or ice is likely to occur.

Rainwater has fallen to the ground, some will seep into the ground as groundwater. Some flow into lakes or rivers which then flow into the sea.

The phenomenon of rainfall that occurred in Belawan Waters for 1 year can be seen in Table 1. This natural process occurs due to too much water vapor being stored so that the clouds can't accommodate the water vapor and fall to the earth.

Table 1. Amount of Precipitation and Number of Rainy Days by Month in Medan Municipality 2021.

Tabel/*Table* 1.2.3 Jumlah Curah Hujan dan Hari Hujan Menurut Bulan di Kota Medan, 2021
Amount of Precipitation and Number of Rainy Days by Month in Medan Municipality, 2021

Bulan *Month*	Stasiun Meteorologi Maritim Belawan *Meteorologi Maritim Belawan Meteorology Station, Medan*	
	Curah Hujan *Precipitation (mm3)*	Hari Hujan *Rainy Days*
(1)	(2)	(3)
1. Januari/ *January*	228,8	22
2. Pebruari/ *February*	30,6	4
3. Maret/ *March*	128,0	14
4. April/*April*	62,0	9
5. Mei/ *May*	31,2	8
6. Juni/ *June*	140,7	16
7. Juli/*July*	149,4	10
8. Agustus/*August*	389,0	20
9. September/ *September*	214,2	17
10. Oktober/ *October*	446,3	15
11. Nopember/ *November*	282,2	27
12. Desember/ *December*	352,4	18

Sources: Medan City in Figure 2021.

TSS (Total Suspended Soil) Analysis using GEE Cloud

The analysis of the Sentinel-2 satellite image using the GEE Cloud can be seen in Figure 3, 4, 5, dan 6. Map of the research location can be seen in **Figure 1.**

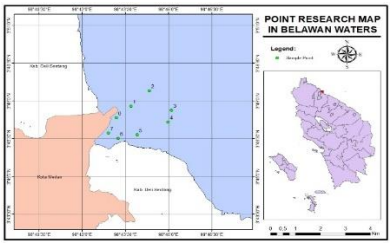

Figure 2. Map of Belawan Waters Research Location 2021.

Sentinel-2 image analysis doesn't require radiometric correction because the value of the image is already a reflectance value. Geometric analysis is also not needed because this study only focuses on the reflectance value of the image. The image used is the Sentinel-2 image with the recording date during the dry and rainy seasons in 2021.

The map of the TSS distribution from February 1st – March 30th, 2021 (Figure 3) and image recording show that at high tide and during the high rainy season, the highest TSS value is 114-124 mg/l and the lowest TSS value is 33-34 mg/l. the highest and lowest TSS values spread to all edges of Belawan Waters and to all river waters leading to Belawan at points 6, 7, 8, and 4, which are red.

TSS distribution map on April 1st – May 30th, 2021 (Figure 4), and image recording show that at high tide and during the high rainy season, the highest TSS value is 40 mg/l and the lowest value is 18 mg/l. This occurs at the research points at 1, 3, and 4 points.

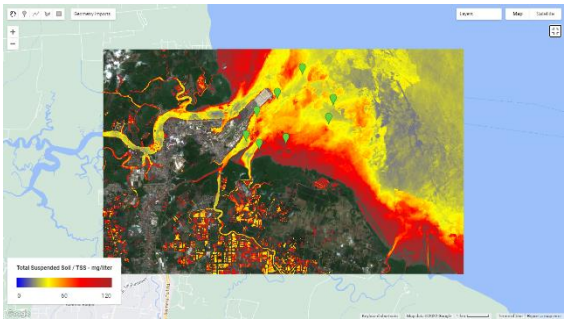

Figure 3. TSS Analysis February 1st – March 30th 2021.

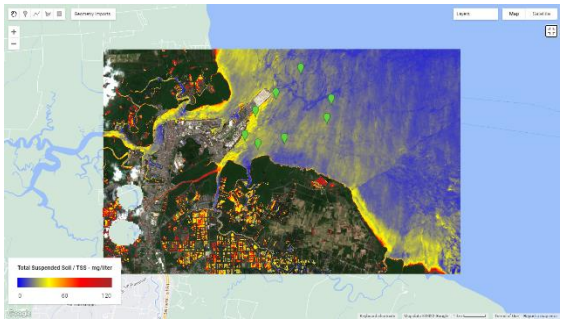

Figure 4. TSS Analysis April 1st – May 30th 2021.

TSS distribution map on October 1st – December 30th, 2021 (Figure 6) and image recording shows that at high tide and during high rainy season, the highest TSS value is 70-62 mg/l and the lowest TSS value is 14 mg/l. This occurs at the research points at 6, 7, and 2 points.

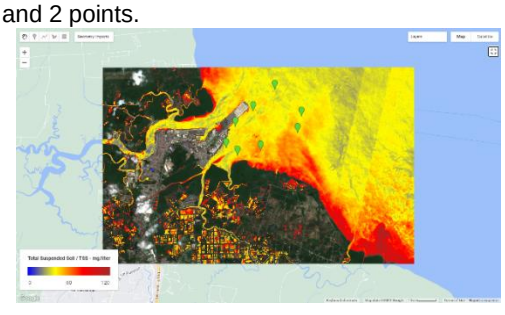

Figure 5. TSS Analysis July 1st – Agustus 30th 2021.

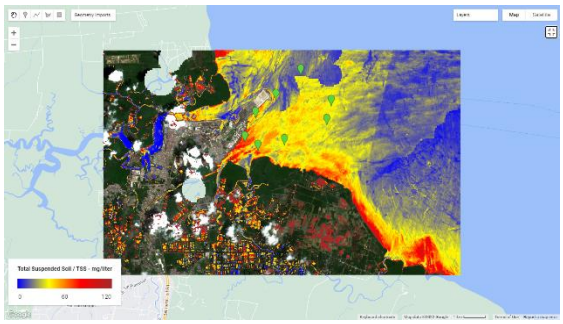

Figure 6. TSS Analysis October 1st – December 30th 2021.

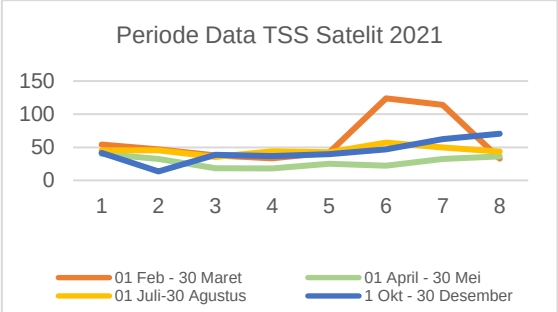

Figure 7. Period of Satellite TSS Data 2021.

Discussion

Based on the analysis at the location of Belawan Waters, North Sumatera Province, it was found that the tidal patterns occurred at the research location were mixed, inclined, and double daily types. The Sentinel-2 image used will show the time at which the image was recorded which, if adjusted for the tides, will result in the position of the waters at high or low tide.

Tidal analysis was carried out, in February 2021 it was found the water level reached 0,105 m higher than MSL and the lowest water level reached 0,32 m indicating the position of high tide towards low tide, in March 2021 it showed the highest water level rise with the altitude is 0,113 m higher than MSL and lowest water level rise is at an altitude of 0,31 m. The results of TSS recording in Belawan Waters for February 1st-March 30th 2021, namely 33-124 mg/l.

In April 2021, it was found that the water level rise was 0,111 m and the lowest water level was 0,34 m, indicating the highest and lowest tide, while the highest water level rise for May was 0,102 m and the lowest water level was 0,42 m. TSS recording results obtained in Belawan Waters from April 1st to May 30th 2021 are 18-40 mg/l.

Tidal analysis was carried out, and in July 2021 it was found the water level reached 0,90 m higher than MSL and the lowest water level reached 0,46 m indicating the high tide position towards low tide, in August 2021 it showed the highest water level rise with a height of 0,93 m higher than MSL and the lowest water level rise at an altitude of 0,31 m. The results of TSS recording in Belawan Waters for July 1st-August 30th 2021, namely 35-57 mg/l.

For the tidal analysis carried out, in October 2021 it was found that the water level reached 0,109 m higher than MSL and the lowest water level reached 0,30 m indicating the high tide position towards low tide, in November 2021 it showed the highest water level rise with an altitude of 0,108 m higher than MSL and the lowest water level rise at an altitude of 0,39 m, and in December 2021 showed the highest water level rise with an altitude of 0,101 m higher than MSL and the lowest water level rise at an altitude of 0,49 m. The results of TSS recording in Belawan Waters for July 1st-August 30th 2021, namely 14-70 mg/l.

Seasonal forecasts based on BMKG data show that in February and March 2021 from the dry season to the rainy season, with a value of 30,6-128 mm^3. April and May 2021 are the levels of the low rainy season leading to the dry season, with a value of 31,2-62 mm^3. July and August 2021 are high rainy seasons, with a value of 149,4-389 mm^3. October-December 2021 is a very high rainy season, with a values of 282,2-352,4 mm^3, the results of tidal analysis in the season show that the dry season in April and May 2021 shows the waters in a low tide and in the rainy season the waters are in a very high tide position, namely October-December 2021.

Figure 3 shows that the TSS results obtained for February 1st-March 30th 2021 are spread around the coast of Belawan to the Belawan Port, but dominantly towards the Belawan coast to the rivers in Belawan. This is different from the TSS results for July 1st-August 30th 2021, which are not widespread to all Belawan shores and are dominant towards the rivers in Belawan. Meanwhile, the TSS results for October 1st to December 30th 2021 are spread unevenly to all Belawan shores and a little at the port, but are dominant towards the rivers in Belawan. And the TSS results for April 1st-May 30th 2021 (Figure 4) show that the TSS doesn't spread evenly to all waters up to the Belawan coast, but spreads to the rivers in Belawan.

The TSS value is higher in the rainy season compared to the dry season due to the flow of rivers entering Belawan Waters with more water intensity and the tides affect the distribution pattern of TSS where at high tide the distribution pattern will lean towards the estuary due to input from the Malacca Strait and at low tide in the deep waters by the bay.

CONCLUSION

Based on the results of the analysis of the TSS study using the Sentinel-2 TOA Reflectance image, the analysis shows that the TSS value in 2021 in the dry season has a lower value than in the rainy season. So, season influence can determine the direction of TSS distribution pattern, both tidal factors and weather conditions such as rain and dry season. Tide effect on TSS distribution pattern in Belawan Waters causes the TSS value at high tide to be higher than at low tide. Sentinel-2 TOA Reflectance Data imagery can be used to map the TSS distribution pattern in the Belawan Waters area.

REFERENCES

Bae, H. K. (2013). Changes of river's water quality responded to rainfall events. *Environment and Ecology Research*, 1(1), pp. 21–25.

BMKG (2021). Prakiraan Musim Hujan 2019-2021 di Indonesia, pp. 1–134. https://sumut.bps.go.id/indicator/151/340/1/curah-hujan-dan-banyaknya-hari-hujan-di-sampali.html.

BPS. 2021. Book entitled: “Kota Medan dalam Angka (Medan Municipality in Figures) 2021”, p.627. https://medankota.bps.go.id/publication/2021/02/26/695922e9701d335f2207cf74/kota-medan-dalam-angka-2021.html.

Chen, J., W. Zhu, Y. Q. Tian, Y. Zheng & L. Huang. 2017. Remote estimation of colored dissolved organic matter and chlorophyll-a in Lake Huron using Sentinel-2 measurements. Journal of Applied Remote Sensing 11(3) : 036007-1-036007–036015.

Effendi, H. (2003). *Telaah kualitas air, bagi pengelolaan sumber daya dan lingkungan perairan*. Kanisius.

ESA (2015). *Microbial Adaptation*, *Sentinel-2 User Handbook*. European Space Agency. doi:10.1021/ie51400a018.

Gu, Y. G., & Y. P. Gao. 2019. An unconstrained ordination- and GIS-based approach for identifying anthropogenic sources of heavy metal pollution in marine sediments. Marine Pollution Bulletin 146 : 100–105.

Hua, A. K. 2017. Identifying the source of pollutants in Malacca river using GIS approach. Applied Ecology and Environmental Research 15(4) : 571–588.

Juliasih, N. L. G. R., D. Hidayat, M. P. Ersa, & Rinawati. 2017. Determination of Nitrite and Nitrate Levels in Lampung Bay Waters as an Indicator of Water Environmental Quality. Analytical and Environmental Chemistry 2(2) : 47–56.

Kamal, A. N., N. S. Muhammad, & J, Abdullah. 2020. Scenario-based pollution discharge simulations and mapping using integrated QUAL2K-GIS. Environmental Pollution 259 (113909) : 1-10.

Kamara, S. M. 2019. Integration of GIS in the Development of an Environmental Cadastre Administrative System for the Environment Protection Agency Sierra Leone. Journal of Geographic Information System 11 : 411–428.

Khairul. 2017. Study of Aquatic Physicochemical Factors on Aquatic Biota in the Belawan River Ecosystem. Proceedings of the Multidisciplinary National Seminar on Science UNA 2017:1132–1140.

Liu, H. *et al.* (2017). Application of Sentinel 2 MSI Images to Retrieve Suspended Particulate Matter Concentrations in Poyang Lake’, *Remote Sensing*, 9(7), p. 761. doi: 10.3390/rs9070761.

Mir, A., J. Piri & O. Kisi. 2017. Spatial monitoring and zoning water quality of Sistan River in the wet and dry years using GIS and geostatistics. Computers and Electronics in Agriculture 135 : 38–50.

Nasrabadi, T., H. Ruegner, Z. Z. Sirdari, M. Schwientek & P. Grathwohl. 2016. Using total suspended solids (TSS) and turbidity as proxies for evaluation of metal transport in river water. Applied Geochemistry 68 : 1–9.

Qanita, H., S. Subiyanto & H. Hani’ah. 2019. Analisis Distribution Anlysis of Total Suspended Soil and Chlorophyll-a Content in West Semarang Flood Canal Waters using Landsat 8 and Sentinel-2A Imagery. UNDIP Geodetic Journal 8(1) : 435–445.

Saberioon, M., J. Brom, V. Nedbal, P. Souček & P. Císař. 2020. Chlorophyll-a and total suspended solids retrieval and mapping using Sentinel-2A and machine learning for inland waters. Ecological Indicators 113(106236) : 1-11.