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# Spatio-Temporal Variability of Observed Ground Water Level at Peat Hydrology Unit in South Sumatera

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An integrated observation system, so-called SEnsory data transmission Service Assisted by Midori Engineering laboratory (SESAME) has been deployed to measure hydrological and climatological parameters at peatlands of South Sumatera since June 2017. One of the observed hydrological parameters is the Ground Water Level (GWL). This study evaluates the spatio-temporal variability of GWL observed at 4 locations, namely, Peat Hydrology Unit (PHU) Sungai Saleh 1 (SS1), Sungai Saleh 2 (SS2), Sungai Lumpur 1 (SL1), and Sungai Lumpur 2 (SL2). The data covered a period of July 1, 2017 to June 30, 2018. This study focused on analyzing types of observed tides at each SESAME location. It was found that at the study location SL2, SS1, and SS2 the tidal type was a mixed tide prevailing diurnal. On the other hand, the observed GWL at the SL1 was dominated by a mixed tide prevailing semidiurnal. Further analysis on the observed GWL indicates that the lowest GWL was observed in period September-October, while the highest GWL occurs in period March-April. Statistical analysis shows that the observed GWL was significantly correlated with the observed soil moisture at the SL1 and the SL2. The coefficient correlation at those SL1 and SL2 were 0.85 and 0.95, respectively. It was also found that GWL had a significant correlation with Rainfall (RF).



**Keywords:** Ground Water Level, Peat Hydrology Unit, South Sumatera, Tides.

RESEARCH ARTICLE

## 1. INTRODUCTION

Peatland is a wetland ecosystem characterized by high accumulation of organic materials with low decomposition rate. The main distributions of peatlands in Sumatera Island are in Riau, Jambi and South Sumatera [1–3]. The peatland is vulnerable to fire. In 2015, the El Niño event co-occurred with a positive Indian Ocean Dipole (IOD) event. It has been known that El Niño and positive IOD events caused deficit rainfall over the Indonesian region [4, 5]. It caused the extreme climate events in Indonesia and triggered many environmental issues. For example, the forest fire over 2000–2002 which caused a huge area of forest loss in Indonesia [6]. In addition, previous study had also revealed that the fires on the forested peatland and vegetation in Indonesia during 1997 El Niño event released about 0.81 and 2.57 Gt of carbon to the atmosphere [7].

In order to better predict the occurrence of forest fire, particularly the peat fire, since June 2017 Indonesian government through the Peatland Restoration Agency has initiated a direct observation system of hydrological parameters on peatland area in South Sumatera regency so-called a SEnsory data transmission Service Assisted by Midori Engineering laboratory (SESAME). The parameters measured are Rainfall (RF), Skin Temperature (T), Soil Moisture (SM), and Ground Water Level (GWL).

In this study, GWL data was evaluated to determine the spatio-temporal variability of its. In particular, this study is intended to address the following questions:

1. Could we utilize the GWL data to determine the tidal type of PHU?
2. Is there any relation between GWL and other observed parameters measured by SESAME?
3. What is the pattern of GWL on Peatland Hydrological Unit (PHU) of Sungai Lumpur 1, Sungai Lumpur 2, Sungai Saleh 1 and Sungai Saleh 2 in the South Sumatera based on the SESAME data?

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## 2. LITERATURE REVIEW

### 2.1. Peatland in South Sumatera

Peat is defined as soil that is saturated with water and composed of organic soil material in the form of plant debris and decaying plant tissue with a thickness of more than 50 cm. Peat is a wetland ecosystem characterized by the accumulation of organic matter over long period of time. This accumulation occurs because of the slow decomposition compared to the accumulation rate of organic matter.

South Sumatera Province covering about 87,017 km$^2$ is swamp land spread in the eastern part of the region, starting from Musirawas, Muba, OKI, Muaraenim, and Banyuasin districts. According to the Directorate General of Irrigation, swamps that have the potential for agriculture in South Sumatera Province are 1,602,490 ha, consisting of tidal swampland approximately 961,000 ha and non-tidal swamps or swamps of 641,490 ha. Most of the swamp land (1.42 million ha) is peat swamp land. At present, peat swamp forests are one of the most threatened types of wetlands with pressure from various anthropogenic activities in Indonesia.

The ecological characteristics and roles of peat swamp forests are:

1. Peat swamp forest is a formation of wet tropical rainforest that had a very high level of humidity, is an ecosystem that is vulnerable to external disturbances and difficult to recover with high level of biodiversity. Silvicultural systems that rely on succession of natural forests show more success.
2. Dry peatland had non-dry and highly flammable nature, subsurface peat fires will be difficult to extinguish and could damage the structure of peat, reduce the level of permeability in the surface layer and causing peatlands to solidify and reduce the dome surface height peat.
3. Peat play an important role in storing carbon; drying and fire will release carbon bonds into the atmosphere
4. There are two forms of swamp land system, namely: alluvial marine with a mineral soil texture and thin layer of peat, and a rear swamp which forms a thicker peat dome.
5. Canalization can cause drought risk if it is not balanced with good and correct water control.
6. Rehabilitation in areas of peat swamp forest already severely damaged, very difficult and expensive, so that funds could not be provided only from government budgets or community participation/self-help.



Peatlands in South Sumatera Province have thicknesses ranging from very shallow (<50 cm) to deep (200–400 cm), and there is no very deep peat thickness of more than 400 cm. The results of satellite imagery analysis and other supporting data reported by the Peatland Inventory Team that there was an increase in the area of peat swamps with very shallow thickness/depth (<50 cm), from none in 1990 to 159,036 ha in 2002. The very shallow peat (<50 cm) formation is concentrated in areas that have been cleared for agricultural land, namely in the delta area of Telang, Upang, Sugihan Kiri, Sugihan Kanan, Karang Agung and Muara Lakitan. All of these areas are agricultural land and transmigration settlements that have been cultivated intensively, including the rice production centers.

The distribution of peatlands in OKI regency South Sumatera Province in 2002 with a medium thickness (100–200 cm) were recorded as 547,112 ha. It was spread in Pedamaran and Tulung Selapan areas (40 percent), Gajah Mati village (15 percent), and Simpang Heran Beyuku area (45 percent). Most of peatland in Padamaran and Tulung Selapan have been developed into oil palm plantations. Majority peatland in Simpang Heran Beyuku have been converted to the construction of Industrial Plantation Forests (HTI). Meanwhile, the peatland in Gajah Mati village have become a settlements area.

The distribution of peatland with a medium-thickness (100–200 cm) in Muba and Banyuasin regency are concentrated in the northern side of the Lalan River, starting from the East Great Coral to Bayung Lincir and spreading northeast to the border with mangrove forests in Sembilang National Park.

The distribution of peatland with a depth/thickness of 200–400 cm is only found in the western and eastern regions of the estuary of the Lematang River–Musi River in Muara Enim regency and small portion in the Gelumbang district, which is thought to play a role as a retention area when overflow Musi river from the Lematang River. In general, the area is still covered with dark vegetation and bushes and the entire area is in the process of being converted into oil palm plantations.

Over the past decade many areas of peat land have been cleared for various purposes, such as agriculture and plantations. On smaller scale, agricultural activities are carried out through a transmigration program. While on larger scale, the opening of peat land is intended to take timber stands on it and to develop plantations, especially oil palm. Many of the peatland clearing activities are motivated by short-term economic interests by defeating long-term environmental interests.

From the study of the spread of peat conducted by Wetlands International Indonesia Program (WI–IP) with the South Sumatera Forest Fire Management Project-European Union (SSFFMP-EU) in the HRGMK (Hutan Rawa Gambut Merak Kepahiyang) region, it can be seen that of the total 271,000 ha of its area, around 210,000 ha are peatlands with thicknesses between less than 1 m to 7 m, with two peat domes, which are between the Merang and Kepahiyang rivers and between the Kepahiyang river and the upstream–upstream river which empties into Sembilang National Park. Therefore, this area should be considered as one of the remaining important natural peat swamp forests in South Sumatera Province. This peat swamp forest is a wildlife habitat and corridor between Berbak National Park in Jambi and Sembilang National

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Park in South Sumatera. The area is an area that has an important function as a counterweight to the functions of the water system and is a buffer for the unity of the Peat Swamp Forest ecosystem that lies between Berbak National Park and Sembilang National Park.

One of the activities that has the most potential to increase the rate of degradation of peat swamp forests in Indonesia is the activity of making canals/ditches (canalization), both those built legally and illegally in and around peatland forests. The canalization causes disruption of the hydrological system of forest and peatland areas, because the canals that are built cause water on peatlands to quickly exit and the carrying capacity of groundwater becomes small and the water level on peat lands decreases dramatically. This condition causes forests and peatlands to dry up in the dry season and vulnerable to fire hazards. The multidisciplinary study conducted by WI-IP at the location of the Merang Kepahiang Peat Swamp Forest stated that there were around 113 canals on the Merang River, not including the tributaries and rivers around it. These canals are generally made by illegal loggers to help transport/dispose of wood from peat swamp forests.

Canalization is carried out by simple sealing in the trenches to control water according to their needs, not to prevent peat damage from drought and fire, but only to facilitate the removal of wood from peat swamp forest to the main river. Construction of the bulkhead is very simple, composed of materials available around the ditch. In addition to influencing drainage, when ditches are built many trench excavation materials (such as mineral soil sludge, fresh plant debris, or peat) are wasted into the river. Nutrients that should be stored in peat soils are also dissolved in the flow of water. Such conditions cause changes in the width and depth of the river and river water quality.



The threat of fire is very large, the losses caused by peat fires include loss of germplasm sources including forest products and all biodiversity in them as well as loss or reduced function of peat as a store of water and carbon. Fires can also threaten the presence of people around them, including public facilities such as wells and gas pipelines which are very vulnerable in the event of surrounding forest and land fires. Efforts to overcome forest and peat land fires are very difficult. An effective effort is to prevent fires by keeping peat swamp forests wet so they are not flammable, and by covering existing trenches [8].

### 2.2. Sesame (Sensory Data Transmission Service Assisted by Midori Engineering Laboratory)

The SESAME system is a telemetry system. The SESAME system can be expected in many ways even only for climate change countermeasures. The demand for the telemetry system is estimated more than 14,000 measurement spots for four application cases such as (i) control of the ground water level in peat land, (ii) estimation of the immobilized carbon dioxide amount in peat forest, (iii) early warning system against floods and other natural disasters, and (iv) weather observation. Regarding market size, Indonesia is considered to have great demand for telemetry systems.

The SESAME system uses widely available parts in its structure, and therefore subject to the risk of low-quality imitation products despite its ease of maintenance. It is planned to establish the SESAME consortium in Indonesia for sharing the collected data among the related organizations, and it would result in the absolute superiority of the SESAME system.

In its current condition, the water level, which is one of the most important data for dam operation, is hourly read through the water gauge by direct observation, as such, the planning as the multi-purpose dam to properly distribute water and immediate actions against flooding cannot be done. The pilot survey was planned and conducted to demonstrate that the SESAME system can perform the real-time measurement of water level and is resistant to hydrogen sulfide and high humidity in the field. In the survey, the measurement and transmission of the data to the server were continued with regard to the water level, rainfall, and air temperature for about two months since the system was installed in October 2013.

The water level observation by the SESAME system has proved that the system works effectively since the SESAME data reconciled with the visually observed data. No problem was found in respect to continual data collection and durability for the period of two months. In comparison with the Water system, the SESAME system demonstrated its clear superiority in aspects such as product credibility, field data collection, data transmission and processing, etc. This verification activity was introduced in one of the leading local news.

The simultaneous measurement of the ground water level and the ground movement was conducted at the 5 observing locations. The verification results and the study are described as follows:

1. No problem was found for the measurement in peat land, data analysis of which shows the linear relation of the ground movement to the ground water level with high accuracy. It also clarifies that error correction with the data of ground water level is required in addition to the remote sensing measurement for accurate estimation of the carbon emissions from the peat land.
2. The measurement went smoothly, which concluded that there is no problem with data transmission even in hot and humid peat forest. The measured data of aging change of tree reconciled with the general knowledge about tree growth. Also when the result observed by a satellite is to be verified, it became clear that the ground measurement using the SESAME system could enhance the accuracy much more easily than the current practice since it can narrow the measurement interval in terms of time and space with no trouble.

3. It was verified that the ZigBee connection used by SESAME has sufficient transmission capability for the estimation of carbon fixation amount in forest since the effective transmission distance observed in a matured forest was 85 m. However, for transmitting a still picture, it turned out that a faster modem was required [9].

The SESAME was installed in 17 locations in Indonesia, in South Sumatera there are 8 locations of SESAME. The eight locations in South Sumatera are Peat Hydrology Unit (PHU) Sungai Lumpur 1, PHU Sungai Lumpur 2, PHU Sungai Saleh 1, PHU Sungai Saleh 2, PHU OKI1, PHU OKI2, PHU MUBA1, dan PHU MUBA2.

### 2.3. Tidal

Tidal is a natural phenomenon in the form of periodic seawater movements which are caused by gravitational forces and also the attractive forces by other objects such as the sun (solar eclipse), the moon (lunar eclipse) and so on. Tides arise as an effect of gravity and centrifugal force. This gravitational effect is greatly influenced by the masses and is not too influenced by distance.

The gravity used is greater than the sun. Even though the size of the moon is much smaller than the sun, the moon turns out to have a tensile force that is twice as large as the sun's attraction in causing tides because the distance is closer to the Earth. This gravitational pull draws seawater towards the moon and also the sun and produces two gravitational tides or bulges in the sea.

Knowledge of tides is very useful for a variety of purposes, ranging from navigation, hydrographic problems to planning sea or beach buildings. As a periodic phenomenon, tides can be predicted. According to Thomson the amplitude and phase of each tidal component can be calculated from observations, and because the period of each component can be known from the theory of harmonic analysis, tides can be predicted at any place on earth.

The least square method calculation is done by ignoring meteorological factors. With the least square method, the solution obtained using linear equations will produce: mean sea level (MSL), amplitude of each tidal component, and phase of each tidal component.

Generally, there are 3 types of tide, namely diurnal, semi diurnal and mixed tides. A diurnal tide has one episode of high water and one episode of low water each day. A semi-diurnal tide has two episodes of equal high water and two episodes of low equal water each day. Mixed tides, like the semidiurnal tide, can have two episodes of high water and two episodes of low water per day. In the mixed tide prevailing semidiurnal, the first tidal waveform is not the same as the second (asymmetrical) tidal wave and its shape tends to be semidiurnal. Meanwhile in the mixed tide prevailing diurnal the first tidal waveform is not the same as the second (asymmetrical) tide and the shape is inclined to diurnal [10–12].

## 3. METHODOLOGY/MATERIALS

Previous research to obtain tidal types of rivers in South Sumatera has been carried out in Boom Baru river and Tanjung Buyut river, both of which have the same tidal type, namely the diurnal type. This study used the least square method [13]. Meanwhile research on the correlation between hydrological parameters and climatological parameters has been obtained: a strong correlation between GWL and RF [14, 15], a strong correlation between RF and SM in low soil layers [16], and a strong correlation between GWL and T [15]. Another studies have found a strong correlation between hydrological characteristics

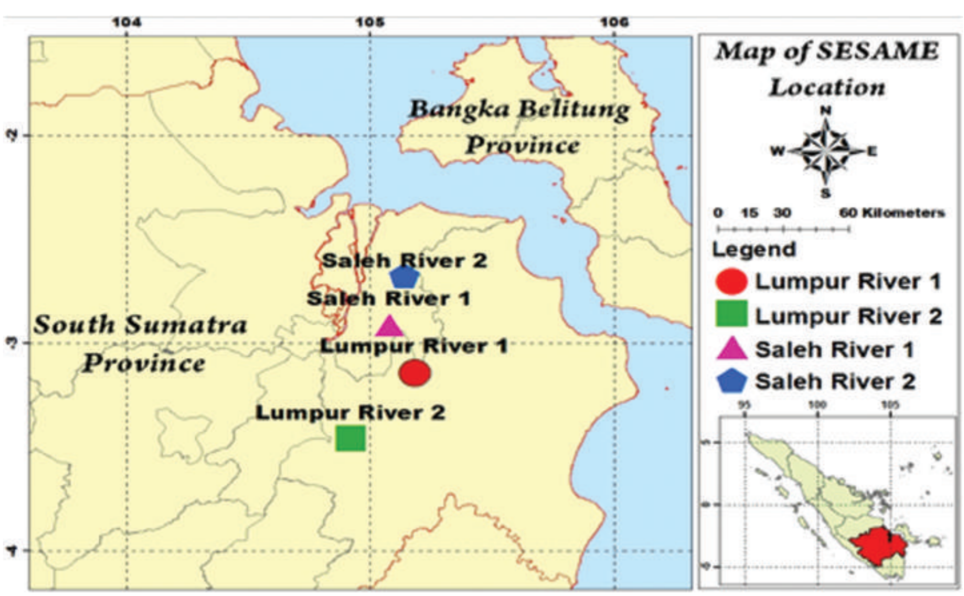


**Fig. 1.** Map of the four study locations in the South Sumatera.

and climatological variations on peat swamp areas around Mahakam and Kapuas [17].

Based on the previous studies, we used the same method in determining the type of tides on SL1, SL2, SS1, and SS2, and looking for correlations of GWL versus RF, GWL versus SM, and GWL versus T.

This study conducted at four Peatland Hydrological Unit (PHU) in South Sumatera, namely PHU Sungai Lumpur 1 (SL1), Sungai Lumpur 2 (SL2), Sungai Saleh 1 (SS1), and Sungai Saleh 2 (SS2). The location coordinates of this study area were (−3, 143, 105, 184) for SL1, (−3, 458, 104, 921) for SL2, (−2, 911, 105, 082) for SS1, and (−2, 677, 105, 143) for SS2. The map of these locations is showed at Figure 1.

In order to answer the questions in Introduction, we evaluate the parameters measured by SESAME. These parameters are GWL, SM, RF, and T. The data downloaded from the SESAME system is hourly data for the period 1 July 2017 to 30 June 2018. Especially for GWL data shown in Figure 2.

The main study aimed to determine the type of tide on study locations. To determine the tidal type, the value of the Formzahl number must be calculated using the following equation [13]:

$$F = \frac{O_1 + K_1}{M_2 + S_2} \tag{1}$$

where: $F$ represents Formzahl Numbers, $K_1$ represents amplitude of the main single tidal component caused by the sun's attraction, $O_1$ represents the amplitude of the main single tide component caused by the lunar attraction, $S_2$ represents the amplitude of the main double tide component caused by the sun's attraction, $M_2$ represents the main double tide component amplitude caused by the lunar attraction.

The determination of these components is carried out using the Least square method assisted by excel-based computer program. The examples of the calculation results can be seen in Table II. After obtaining the values of these components, the $F$ value is calculated using Eq. (1). Based on the obtained $F$ value, the tidal type can be determined using the criteria as listed in Table I [13].

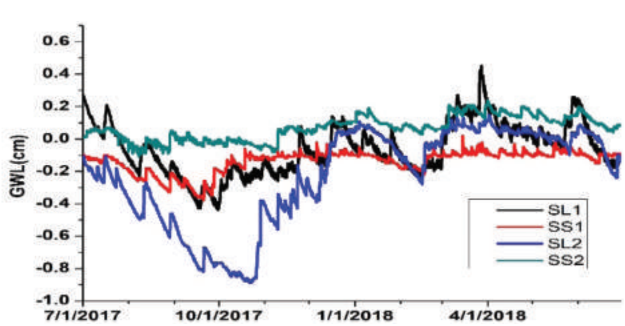


**Fig. 2.** Graph of GWL hourly data at the four study locations.

**Table I.** The value of $F$ and tidal type.

| $F$ value | Tidal type |
|---|---|
| $F \leq 0.25$ | Semi-diurnal tide |
| $0.25 < F \leq 1.50$ | Mixed tide prevailing semidiurnal |
| $1.50 < F \leq 3.00$ | Mixed tide prevailing diurnal |
| $F \geq 3.00$ | diurnal tide |

Another purpose of this study is to find out the correlation of GWL versus RF, GWL versus SM, and GWL versus T. The statistical calculations are performed using linear regression equations and linear correlation coefficient. Linear regression analysis is used to form relationships between variables. This analysis can estimate the value of a variable with other variables through an equation:

$$y = a + bx \tag{2}$$

where $a$ is the intercept and $b$ is the slope or gradient line. $y$ is the dependent variable and $x$ is independent regression. $a$ and $b$ constants can be calculated using the following equation:

$$a = \frac{(\sum y \sum x^2) - (\sum x \sum xy)}{N(\sum x^2)(\sum x)^2} \tag{3}$$

$$b = \frac{N(\sum xy) - (\sum x \sum y)}{N(\sum x^2)(\sum x)^2} \tag{4}$$



Correlation is a way to determine how well two (or more) variables vary in time or space. The correlation coefficient can be written using the equation [18]:

$$r_{xy} = \frac{1}{N-1} \sum_{i=1}^{N} \frac{(xi - x) - (yi - y)}{s_x s_y} \tag{5}$$

where $s_x$ and $s_y$ are standard deviations for two data records. For $r = \pm 1$, the data point $(x, y)$ is along a straight line and the sample is said to have a perfect correlation. $s_x$ and $s_y$ are defined as:

$$s_x = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (x_i - \bar{x})} \tag{6}$$

## 4. RESULTS AND FINDINGS

### 4.1. Tidal Type

The method used to determine the type of tide in this study is the least square method. The data is hourly GWL data from 1 July 2017 to 31 July 2017. The calculation process uses a computer program that is run with Excel. An example of the output table as a result of the calculation is shown in Table II. Table II is the result of the calculation for the location of SL1. From Table II, it can be seen some information such as average water levels ($Z_0$), $K_1$, $O_1$, $S_2$, $M_2$, $F$, and tide types.

A results summary of the least square method calculation for the four research locations is shown in Table III.

**Table II.** The results of least square method of SL1 location.

| Constituents | Symbol | Period (hour) | $\omega$ (rad/ hour) | A | B | Go phase | Amplitude (cm) |
|---|---|---|---|---|---|---|---|
| Average water level | $Z_0$ | | – | – | – | −2.7052 | |
| Main lunar constituent | $M_2$ | 12.4206 | 0.50587 | 5.2529 | 3.1189 | 30.6999° | 6.1091 |
| Main solar constituent | $S_2$ | 12.0000 | 0.52360 | 0.9420 | 33.7805 | 88.4027° | 33.7936 |
| Lunar constituent, due to earth-moon distance | $N_2$ | 12.6582 | 0.49637 | 0.4099 | −3.1113 | 277.5059° | 3.1382 |
| Soli-lunar constituent, due to the change of declination | $K_2$ | 11.9673 | 0.52503 | −7.3041 | −30.9282 | 256.7124° | 31.7790 |
| Soli-lunar constituent | $K_1$ | 23.9346 | 0.26251 | −4.0308 | −20.5858 | 258.9213° | 20.9768 |
| Main lunar cnstituent | $O_1$ | 25.8194 | 0.24335 | 2.3986 | 2.0130 | 40.0044° | 3.1314 |
| Main solar constituent | $P_1$ | 24.0658 | 0.26108 | 0.4672 | 23.2402 | 88.8482° | 23.2449 |
| Main lunar constituent | $M_4$ | 6.2103 | 1.01174 | −0.1420 | 0.1189 | 140.0669° | 0.1852 |
| Soli-lunar constituent | $MS_4$ | 6.1033 | 1.02947 | 0.0290 | −0.0220 | 322.7863° | 0.0364 |

*Notes*: Formzal number $F = 0.62$. Tidal type: Mixed tide prevailing semidiurnal

**Table III.** The component value and tidal type for the study locations.

| PHU | $K_1$ | $O_1$ | $S_2$ | $M_2$ | $F$ | Tidal type |
|---|---|---|---|---|---|---|
| SL1 | 0.2468 | 0.2435 | 0.5858 | 0.2106 | 0.62 | Mixed tide prevailing semidiurnal |
| SL2 | 0.3505 | 0.3146 | 0.2041 | 0.0991 | 2.19 | Mixed tide prevailing diurnal |
| SS1 | 0.5993 | 0.0857 | 0.2177 | 0.0225 | 2.85 | Mixed tide prevailing diurnal |
| SS2 | 1.7219 | 0.1307 | 1.0764 | 0.0728 | 1.61 | Mixed tide prevailing diurnal |

Table III shows that the tidal type on peat land in South Sumatera is not the same as the tidal type in the river in South Sumatera which generally has a diurnal type [13]. This indicates that tides in seawater do not have a direct impact on tides of peatland. This is estimated because the GWL of peatlands is strongly influenced by the intensity of the RF. This is confirmed by the results of calculations on the correlation between GWL and RF which shows a significant correlation as shown in Table IV.



The other output of this least square method is the tide height value calculated and observation data. Based on these data, a tide height graph can be made as shown in Figure 3. The graphs in Figure 3 are based on calculation data for the four research locations SL1, SL2, SS1, and SS2.

Figure 3(a) shows the mixed tide prevailing semidiurnal, because the first tidal waveform is not the same as the second (asymmetrical) tidal wave and its shape tends to be semidiurnal. Meanwhile Figures 3(b–d) show the mixed tide prevailing diurnal, because the first tidal waveform is not the same as the second (asymmetrical) tide and the shape is inclined to diurnal.

From Figure 3(a), it can be seen that the tide height in SL1 varies from 5.3 cm to 7.8 cm. Further studies at Figures 3(a) until (d) were found that the lowest tidal height of −22.9 cm occurred in SL2 and a height of 7.8 cm occurred in SL1.

**Table IV.** The value of $r$ for the four study locations.

| Correlated parameters | $r$ SL1 | SL2 | SS1 | SS2 |
|---|---|---|---|---|
| GWL versus SM | 0.85 | 0.95 | 0.32 | 0.38 |
| RF versus GWL | 0.59 | 0.46 | 0.56 | 0.57 |
| T versus GWL | 0.23 | 0.07 | 0.40 | 0.07 |

Based on the four graphs, it is evident that the GWL observation data on a peatland can be used to determine the type of tides on these peatlands using the least square method.

### 4.2. Correlation of GWL versus RF, GWL versus SM, and GWL versus T

The correlation coefficient ($r$) values of GWL versus SM, RF versus GWL, and T versus GW have been calculated using equations (2) until (6). The data used is monthly average data of GWL, RF, SM, and T from 1 July 2017 to 30 June 2018. The graph of the results at the SL1 location is shown in Figures 4–6.

From Figure 4, it can be seen that the correlation between RF and GWL is significant because it has a value of $r = 0.59$, where the tendency of the graph to be higher in RF is as high as the height of GWL.

Figure 5 shows that GWL has a very significant correlation with SM because the value of correlation coefficient is almost close to 1, which is $r = 0.85$. While in Figure 6 it can be seen that T has no correlation with GWL.

The recapitulation of $r$ values for each location is shown in Table IV. Table IV indicates that significant correlation occurs in GWL versus SM at the SL1 and the SL2 where $r$ values are 0.85 and 0.95, respectively. In Table IV it also shows that the correlation between GWL and RF is significant where the mean value of $r$ at the four study locations is 0.55. Meanwhile the correlation between GWL and T is not significant because the average value of $r$ is only 0.19.

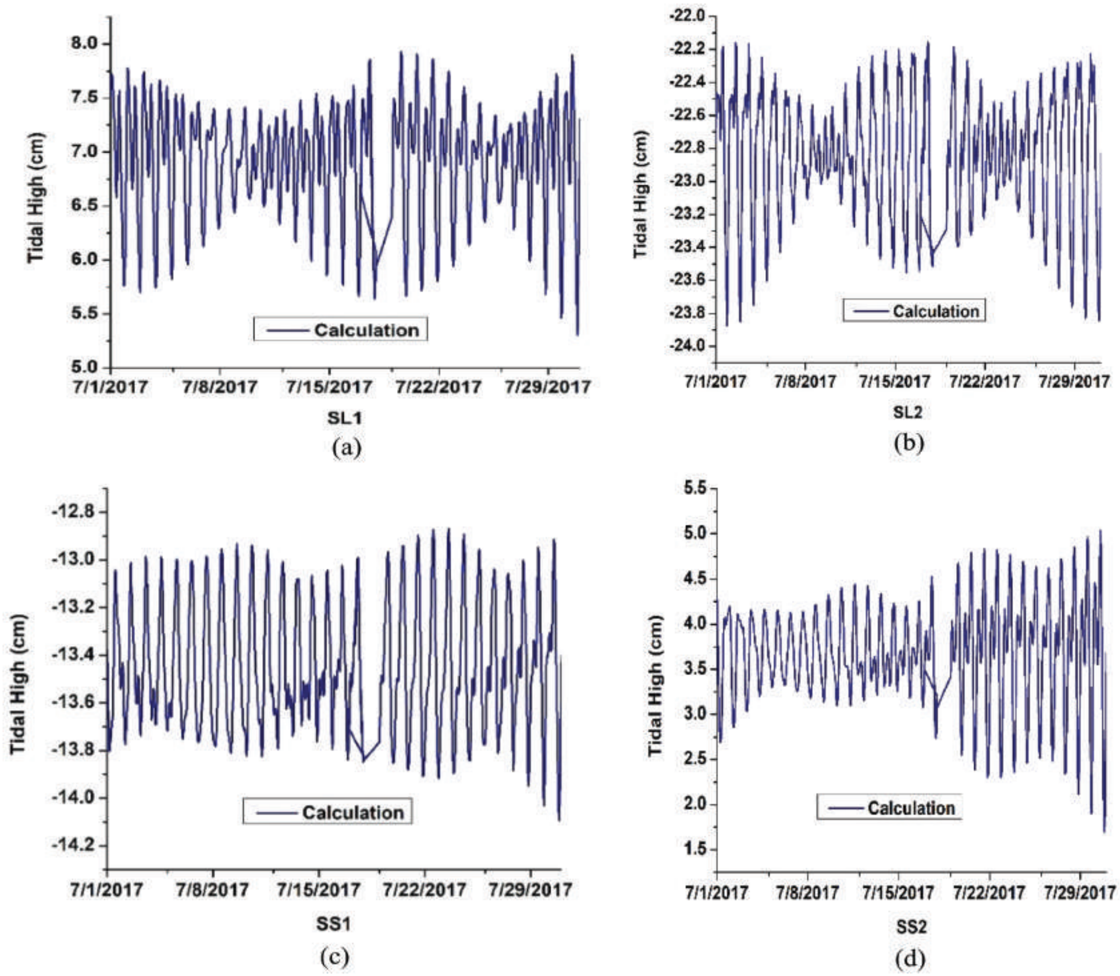


**Fig. 3.** Graphs of tidal high at four study locations.

There is a question that arises from Table IV, why is the correlation between GWL and SM at the location of SL1 and SL2 very high while in locations SS1 and SS2 are relatively low? To answer this question, further research is needed on the structure and types of peat soil constituents in these locations.

Further study in Figure 2 obtained that the lowest GWL occurs around September and October, while the highest GWL occurs around March and April. This is because

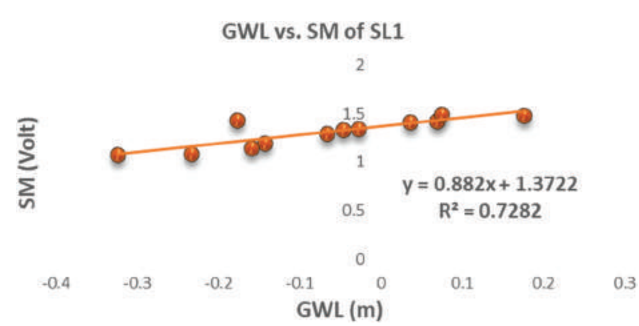


**Fig. 5.** Graph of correlation between GWL and SM of SL1.

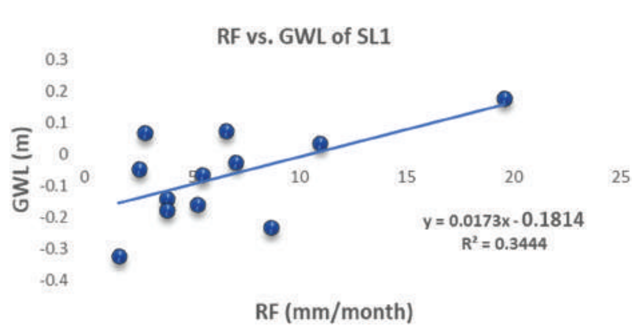


**Fig. 4.** Graph of correlation between RF and GWL of SL1.

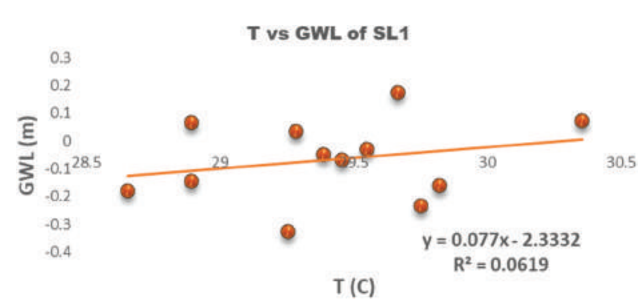


**Fig. 6.** Graph of correlation between T and GWL of SL1.

during September–October in South Sumatera is the end of the dry season, and in the period March–April is the end of the rainy season. Based on this fact it can be concluded that the GWL value depends on RF.

## 5. CONCLUSION

The evaluation of Groundwater Level (GWL) characteristics has been carried out from four peatland study area in South Sumatera, namely Sungai Lumpur 1, Sungai Lumpur 2, Sungai Saleh 1, and Sungai Saleh 2 which were recorded by the SESAME system. It appears that the SESAME system provides valuable GWL data because it can be used for determining of the tidal types in all four study locations. It was found that the tidal type on peat land in South Sumatera was different from the tidal type on the river in South Sumatera.

Statistical analysis shows that GWL correlates significantly with rainfall and soil moisture. Meanwhile, the GWL data can inform when the low GWL will occur that it can be used to monitor peat fires.

It would be very interesting if further research was conducted on the correlation between GWL and tidal type with the number of hotspots that occurred during the extreme dry season (July–October) for fire disaster mitigation.

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