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ESTIMATING GROUNDWATER LEVEL IN PEATLANDS BY USING SUBMERSIBLE SENSOR

Pendugaan Tinggi Muka Air Tanah Pada Lahan Gambut dengan Menggunakan Sensor Submersible

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ABSTRACT

Peatland fires pose a significant challenge in peatland management, with declining groundwater levels being a contributing factor. Real-time monitoring of groundwater levels (GWL) is essential to address this issue effectively. This study examines GWL data collected from submersible sensors and manual readings in peatlands of Tangkit Baru and Pematang Rahim villages, Jambi Province. Results reveal an increase in GWL in Tangkit Baru coinciding with rising precipitation, while Pematang Rahim experiences a contrasting decrease despite heavy rainfall. Statistical analysis, specifically t-tests, indicates no significant difference ($p > 0.05$) between the two measurement methods. However, slight discrepancies (0.1-1 cm) between submersible sensor and manual measurements underscore the importance of sensor maintenance for accurate GWL assessment.

Keywords: Peatlands, sensors, groundwater level

ABSTRAK

Kebakaran lahan gambut menjadi salah satu permasalahan serius dari pengelolaan lahan gambut. Salah satu faktor yang memengaruhi kebakaran lahan gambut ialah tinggi muka air (TMA) yang menurun sehingga perlu dilakukan pemantauan secara real-time. Data yang dikumpulkan adalah data TMA yang diperoleh dengan menggunakan sensor submersible dan manual. TMA yang didapatkan pada lahan gambut di desa Tangkit Baru mengalami kenaikan ketika curah hujan meningkat, berbeda dengan TMA di desa Pematang Rahim yang cenderung tidak mengalami kenaikan ketika terjadi hujan yang cukup lebat. Hasil t-test pada perbandingan pengambilan sampel TMA menunjukkan nilai 0,052 yakni lebih dari 0,05 yang menandakan tidak ada perbedaan antara kedua pengukuran. Perbandingan antara pengambilan dengan sensor submersible dengan manual memiliki selisih 0,1-1 cm, sehingga hal ini menunjukkan bahwa estimasi TMA dengan sensor submersible dapat diterima, namun perlu dilakukan pemeliharaan lebih lanjut untuk mendapatkan data yang lebih akurat.

Kata kunci: Lahan gambut, sensor, tinggi muka air tanah

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INTRODUCTION

Jambi Province has a peat area of 736.227,20 ha, or around 14% of the area of Jambi Province (Zainuddin *et al*. 2019). This are spread across six districts, namely East Tanjung Jabung Regency, covering an area of 311,992.10 Ha. Muaro Jambi Regency (229,703.90 Ha); West Tanjung Jabung Regency (154,598 Ha), Sarolangun Regency (33,294.20 Ha), Merangin Regency (5,809.80 Ha), and Tebo Regency (829,20 ha) (Nurjanah *et al*. 2013).

Peatland is a soil layer rich in organic matter, initially formed from the remains of plants that have not fully decomposed due to water-saturated and nutrient-poor environmental conditions (Oktiana *et al*. 2017). Generally, peatland has characteristics of being unable to support heavy loads or prone to subsidence, capable of absorbing water up to 13 times its weight when the peat is dried (Saharjo *et al*. 2018). Tropical peatlands offer numerous benefits to the Earth's ecosystem, including a global carbon sink capable of storing up to 5800 tons of carbon per hectare at a depth of 10 meters (Andesmora 2021). However degraded tropical peatland ares is provide to be fires bring the Peatland fires an issue in managing peatlands. This situation brings the important of the community critical for knowledge and skills in preventing and controlling peatland fires.

The utilization of technology may serve as a means for monitoring peatlands, one of them is to monitor the groundwater level (GWL) indicator. The groundwater level in peatlands is defined as the difference in height from the surface of the peat, which may appear generally flat but is, in reality, not flat but rather gently sloping in the field. In the context of peatland, the groundwater level is always influenced by the surface pattern of the peat because groundwater is dynamic. The groundwater level in peatlands is consistently related to peat thickness and surface height, affecting the peat maturity level (Afriyanti 2018).

The condition of peatlands, which can change due to human activity, requires quite intense monitoring; however, due to limited human resources in the field and also the large area of peatlands in Jambi Province, it is necessary to monitor in real-time by sending mitigation data using technological assistance called Internet of Things (IoT). IoT is a technical concept that has a working system on the basis that each electronic device can communicate with each other independently and receive and send data to each other via a network connection. One of several applications is a monitoring or process control system that uses sensors and actuators in a particular environment, such as a smart home (Prakoso *et al*. 2022).

The implementation of IoT involves multiple sensors to observe peatland conditions. In this study, the submersible sensor is employed, which functions to record the groundwater level in peatland. The installed sensors are still in new condition. Thus, further testing is required to assess the accuracy of the recorded groundwater level (GWL). Studying the various factors that causing fires in peatlands is one of the most effective and efficient prevention efforts, considering that extinguishing fires requires quite a large amount of fund, therefore various methods for assessing fires can be used. Remote sensing and the use of multiple sensors can be a solution in predicting peatland fires in Jambi Province. The objectives of this research are as follows: 1) To estimate the accurate groundwater level based on integrated submersible sensors with IoT in peatland and comparing it with manually measured groundwater level (GWL) results, and 2) To analyze the influence of precipitation on the groundwater level (GWL) in peatland.

RESEARCH METHODOLOGY

This research was carried out from September-November 2023 in the peatlands of Tangkit Baru Village, Sungai Gelam District, Muaro Jambi Regency, Jambi Province and Pematang Rahim Village, Mendahara Ulu District, East Tanjung Jabung Regency, Jambi Province. Data processing was carried out at the Forest and Land Fire Laboratory, Department of Silviculture, Faculty of Forestry and Environment, IPB University. Figure 1 shows the administrative map of the two regencies.

Tools used in this research are a tool writer and laptop with some programs like Microsoft Word 365, Microsoft Excel 365, ArcMap 10.8, Arduino 1.8.19, Arduino uno module, and SPSS; Submersible sensors; Microcontroller esp. 32; ADS1115; measuring stick; and Telkom IoT server. Materials used are peatland distribution map from the Mangrove and Restoration

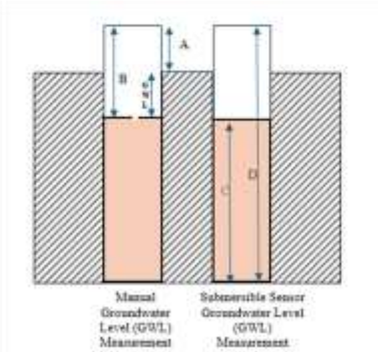

Figure 2 Method for collecting groundwater level data by using submersible sensor (right) and manual readings (left)

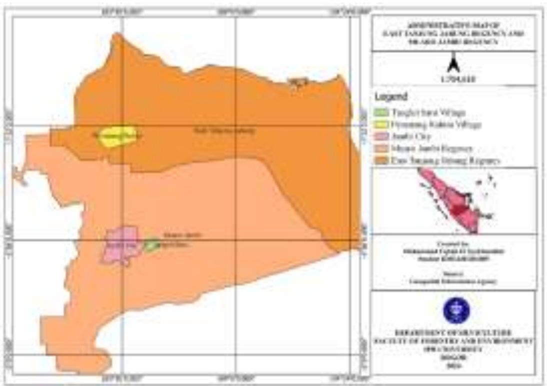

Figure 1 Administrative Map of Tangkit Baru Village and Pematang Rahim Village

Agency Peat (BRGM), groundwater level data from submersible sensors that obtained, manually, and daily rainfall data from NASA GPM.

Data collected is GWL data that divides into two categories, e.g. by using submersible sensors and manual retrieval. Figure 2 provides an overview of the observed groundwater level (GWL) measurements in this study.

The manual readings of groundwater level (GWL) are performed by measuring the length of a measuring stick inserted into the dipwell, from a dry to wet condition, starting from the surface of the PVC pipe (B) and subtracting with the length of the PVC pipe from the surface of the observed peatland (A).

Unlike manual measurements, submersible sensor measurements are conducted by measuring the length of the sensor cable starting from the end of the PVC pipe's surface (D) to the end of the observation well created, then subtracting the groundwater level inside the dipwell ©, and finally subtracting with the height of the PVC pipe from the peat surface (A).

Submersible sensor are types of sensors designed especially for working inside liquid, such as water, with the ability to be waterproof and resistant to a diverse environment. This sensor will integrate with the system module with the declared node address and channel used. Because the system used is a Wireless Sensor Network with tree topology, the desired address should be confirmed. Figure 3 Declaration addresses and algorithm destination addresses are declared 3 from the system at the beginning of programming. Figure 3 shows the working system of submersible sensor.

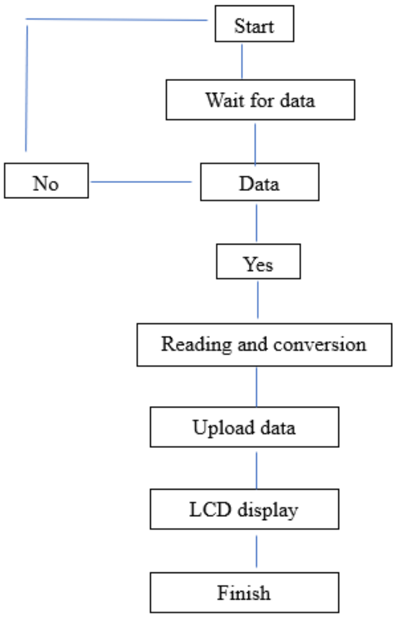

Figure 3 Tree topology of Submersible sensor working system

RESULTS AND DISCUSSIONS

The installation of IoT equipment (Figure 5) was carried out in two places in two different districts, namely in Tangkit Baru Village, Sungai Gelam District, Muaro Jambi Regency and Pematang Rahim Village, Mendahara Ulu District, East Tanjung Jabung Regency. The area in Tangkit Village is formerly peatland, which is often flooded, but the establishment of 11 canals in Tangkit Baru Village with a depth of 1-2 meters and

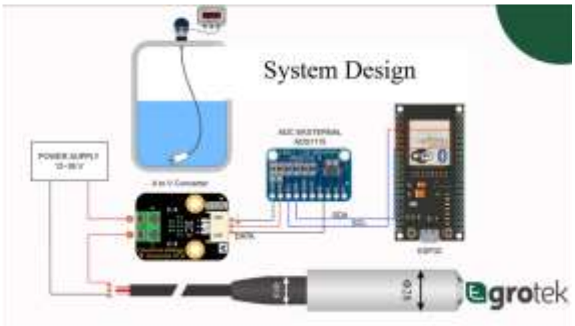

Figure 4 Submersible sensor working system

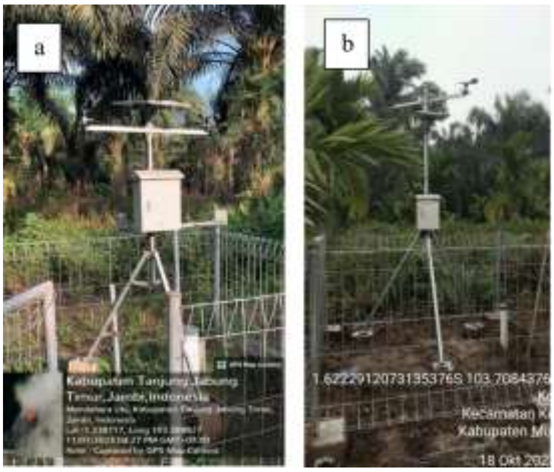

Figure 5 IoT sensors equipment and dipwells: a) Pematang Rahim Village, b) Tangkit Baru Village

Figure 6 The screen display of the Telkom IoT website : a) GWL, temperature, and humidity, b) Wind speed, soil moisture, and precipitation

width of two meters shows that the peat area there has been utilized for pineapple farm. Pematang Rahim Village has a peatland area of approximately 7,655 Ha out of a total area of around 10,617 Ha. Most of the area covered by Sungai Buluh peat protection forest, palm oil plantation, and eucalyptus plantation.

Groundwater Level Observation Using Telkom IoT Console

The submersible sensor used in this research is integrated with the Telkom IoT website console. The advantage of this website lies in its application chart, where we can observe changes in the parameters that being monitor. Typically, when installing devices or sensors integrated through IoT, a website is needed to store the data recorded by these devices. This holds for the submersible sensor installed in two locations, namely in Pematang Rahim and Tangkit Baru villages. Figure 6 provides an overview of the screen display when the sensor is integrated with the Telkom IoT website.

The recorded groundwater level (GWL) data from the IoT sensor indicates an increase in water level on certain days. However, on some occasions, there are discrepancies between measurements from the submersible sensor and manual readings. May occur when measurements are taken when the submersible sensor is under maintenance, leading to a bias in the accuracy of the measurements. The difference can be significant during maintenance, reaching up to -20 cm. This is because the newly installed sensor requires calibration of the GWL data reading on the coding code that has been provided by manual measurements. Wakhid *et al*. (2019) explains that variations in groundwater level measurements in peatland can occur due to several factors, including the difference in the location of dipwells between those near the canal and those far from the canal. This discrepancy is influenced by the nature of water, which tends to flow towards lower areas.

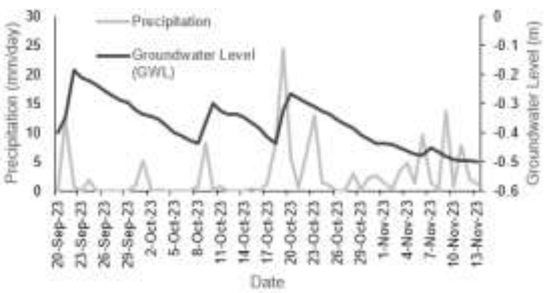

Figure 7 GWL in Tangkit Baru Village with daily precipitation

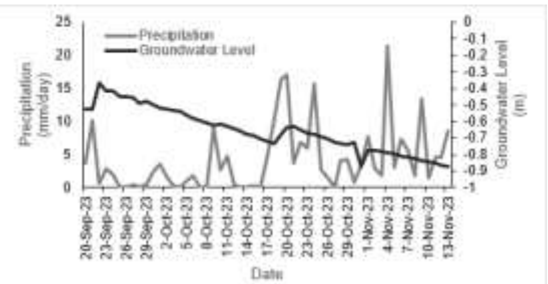

Figure 8 GWL in Pematang Rahim Village with daily precipitation

Therefore, constructing channels in the peatland plays a crucial role in maintaining groundwater levels in the peatland.

Relationship between Precipitation and GWL in Tangkit Baru and Pematang Rahim Villages

Groundwater level is widely used as an indicator in determining the quality of peatlands, especially in preventing fires in peatlands (Putra *et al*. 2008). The government has issued Regulation Government (PP) No. 71 of 2014, stating that peatland can be categorized as damaged if drainage networks are constructed in peat swamp forests, and for cultivation on peatland, if the groundwater level (GWL) is more than 0.4 meters below the surface (PP 71/2014). Figure 7 shows an increase in groundwater level along with increasing rainfall in Tangkit Baru Village. This is in line with Wakhid *et al*. (2019), which states that water level is significantly influenced by precipitation that occurs in an area.

The relationship between precipitation and groundwater level (GWL) in September 2023-November 2023 shows a positive impact of precipitation to GWL where an increase in daily precipitation will be followed by an increase of GWL. This is in accordance with research conducted by Abdillah (2023) that on peatlands whose quality is still maintained, an increase in rainfall will be followed by a rise in groundwater level (GWL). However, in contrast to Figure 7, Figure 8 shows that an increase in precipitation does not result to an increase of the GWL in Pematang Rahim Village.

The peatland in Pematang Rahim Village in Figure 8 shows that the increase of precipitation not giving the significant effect to the increase of GWL. Instead of increase, the GWL in Pematang Rahim Village show the decrease trend, even the area has experienced the high amount of precipitation. This may due to the condition of peatland in the surrounding area that has been degraded (Putra 2018). On the degraded peat, following the land opening and drainage manufacturing, peat water will easily flow out, and therefore the peat becomes dry (Taufik *et al*. 2015. This shows peat has lost the ability to absorb and store water, so there is a very high risk of fire. According to Putra (2018), GWL will return to sound and stable conditions, after the water supply from continuous rain continuously.

Comparison of Manual Readings and Submersible Sensor

Differences in GWL measurement methods certainly may result to the difference of the measurement results, thus it is necessary to compare these methods at least.

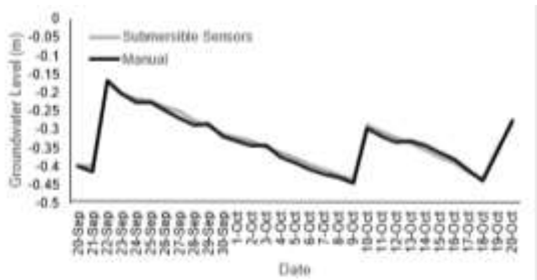

Figure 9 GWL measurements using Manual and submersible sensor in Tangkit Baru

Figure 9 shows a comparison of the GWL data from manual and submersible sensors in Tangkit Baru Village. The same dipwells is used to avoid the errors of data collection.

A comparison of GWL measurements in Figure 9 was carried out using the paired T-test. Based on the results of the t-test, a value of 0.052 was obtained. This value shows that there is no difference found between the two measurements. If the T-test value is less than 0.05, then there is a difference, but if the value is more than 0.05 there is no difference. Based on this result, it clearly shows that the GWL reading from submersible sensor may provide a close value with manual readings.

CONCLUSIONS

The study reveals a positive correlation between precipitation and groundwater level (GWL) in Tangkit Baru Village, suggesting that as rainfall increases, so does GWL. This association implies that the peatlands in Tangkit Baru Village remain relatively preserved, potentially mitigating the risk of peatland fires. Conversely, in Pematang Rahim Village, a negative correlation between precipitation and GWL indicates potential degradation of the peatlands, raising concerns about future forest fire occurrences. Comparative analysis between submersible sensors and manual readings demonstrates a negligible difference of approximately 0.1-1 cm, highlighting the reliability of submersible sensors. However, emphasizing the importance of sensor maintenance is crucial to ensure accurate GWL measurements.

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