Estimation on Water Content in Soil Using Antenna Embedded in Ground for Landslides Prediction System

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***Abstract* — To estimate the water content in mountain locally, a coil antenna sensor embedded in soil was proposed and the capability was evaluated for the landslides prediction system. From the simple field test, the coil antenna sensor installed in this system has a capability to predict the deep-seated landslides as well as the shallow landslides.**

***Index Terms* — Sensor, Landslide, Antenna, and Microwave.**

I. Introduction

In Japan, the number of landslides is increasing because of the torrential rain, recently. From 2009 to 2019, the average number of the landslide was more than 1000 [1].

The landslide is mainly classified into the shallow landslide and the deep-seated landslide. The shallow and the deep-seated landslides occur near the ground and at deep underground, respectively.

The main cause of the landslide is to increase the water content in soil. Time Domain Reflection (TDR) method is mainly used by measuring the water content in the soil now. Unfortunately, this method has only capable of measuring water content near the electrodes in the face of expensive of the TDR device. Another candidate of a technology for landslides estimation is the tank model [2]. But it is difficult to simulate the environment condition such as vegetation, geology, weathering and so on. From these reasons, low-cost and real-time observation systems for monitoring the water content in the soil is required.

With this in mind, the landslide prediction system had been proposed by measuring the difference of the received power level between the direct AM radio broadcasting wave and the reflected one from the target mountain's surface because it was found out that the reflected power of the AM radio broadcasting wave from the target mountain's surface was a function of the averaged water content in soil of all the mountain [3].

To estimate the water content in mountain locally, a coil antenna sensor embedded in soil was proposed and the capability was evaluated for the landslides prediction system in this paper. The details are as follows.

II. Coil Antenna Sensor Embedded in Soil

Figure 1 shows the schematic view of the system to monitor the water content in soil. The embedded coil antenna, which consists of winded copper wire with 100m in length on the surface of the vinyl chloride pipe with 48mm in diameter, receives the AM radio broadcasting wave. The spectrum analyzer is connected to the antenna to measure the receiving level at hourly interval. The measured frequency was set at 1.026MHz because this frequency is that of the closest AM radio broadcasting base station located from 2 km away.

Figure2 shows the measured frequency spectrum of the AM radio broadcasting wave received by the coil antenna sensor embedded inn soil. Well received level with a signal-to-noise ratio of 20dB was obtained.

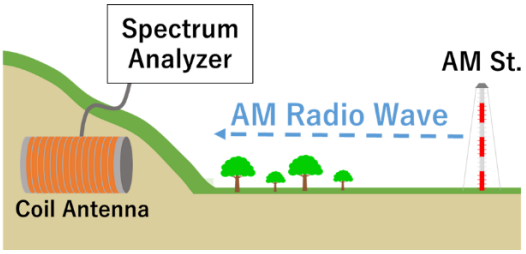

Fig. 1. Overview of monitoring system for water content in soil

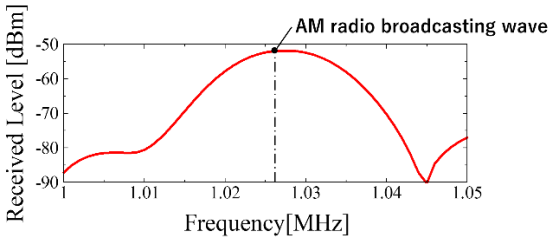

Fig. 2. Measured frequency spectrum of AM radio broadcasting wave by fabricated coil antenna sensor embedded in soil.

III. Experiment

Figure 3 shows a photograph of the coil antenna sensor, which was embedded in soil at a depth of 25 cm. The soil contained 50% coarse graine and the particle size was less than 2.0 mm. For reference, TDR sensor which is an equipment to measure water content based on TDR method was also embedded near the coil antenna sensor.

In this setup, 15L of tap water was sprinkled on the ground and the water content meased by the TDR sensor is shown in Fig. 4 as a orange curve, while the AM radio receiving level meausred by the coil antenna sensor is also depicted in Fig. 4 as a blue curve. This experiment was performed in a sunny winter day. From this result, it is confirmed that the AM radio receiving level was strongly

correlated with the measred water content by the TDR sensor.

Based on the results, the AM radio receiving level as well as whether data such as amount of rainfall, temparature, humidity getting from Japan Meteorological Agency website is monitoring every one hour interval since January 2020.

For an example, tipical data is shown in Fig. 5 when concentrated heavy rain occurred from 5th July to 15th July. The AM radio receiving level is well correlated with the water content and amount rainfall. After rain stopped, the AM radio receiving level slowly decayed while the water content by measuring the TDR sensor quickly decayed. The reason is thought that the coil antenna sensor gets the water content information at deep position under the ground due to the antenna operation, while the TDR sensor get that near the electrode at the neighborhood of the ground surface due to the transmission line operation. It suggests that the coil antenna sensor installed in this system has a capability to predict the deep-seated landslides as well as the shallow landslides.

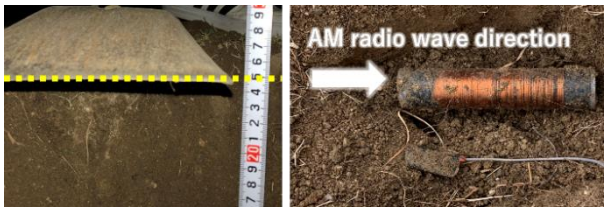

Fig. 3. Photograph of coil antenna sensor embedded in soil

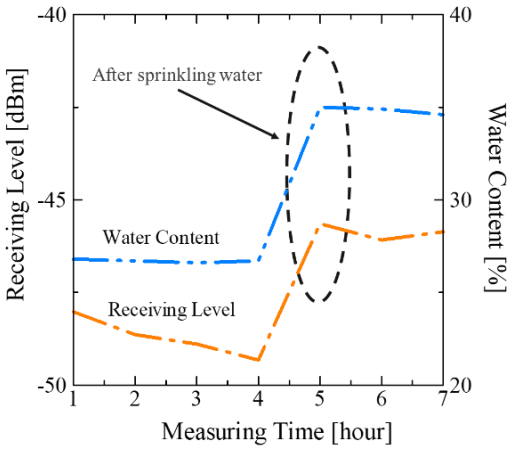

Fig.4. Measured AM radio receiving level (Red) and water content in soil (Blue) versus time.

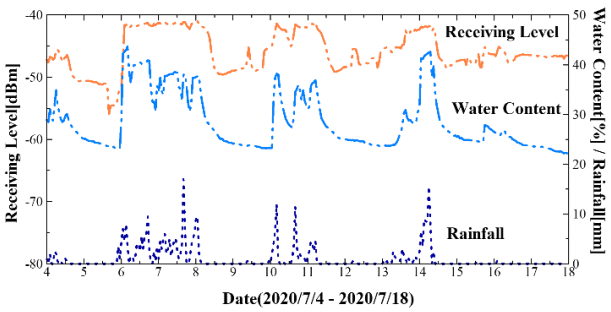

Fig.5. Measured AM radio receiving level (Orange), water content in soil (Blue), and rainfall (Navy blue) in time series.

IV. Conclusion

From this experiment results, it is shown that the water content in soil can be estimated by the embedded coil antenna.

We are planning to do field experiment by fabricating the system combing the antenna with IoT devices.

References

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[3] Kousei Kumahara, Futoshi Kuroki, et al., “A Landslide Prognostication System Based on Bistatic Radar Technology Using AM Radio Waves”, Proc. of RWW (2018).