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Soil moisture measurement tools using SHT11 sensors based on the Internet of Things

Yolanda Karinia[1], Violita Violita[2], Heron Tarigan[3], Nofi Yendri Sudiar[1], Yulkifli[1*]

[1] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang
[2] Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang
[3] BMKG Climatology Station, Sicincin, Padang Pariaman

**Corresponding author: yulkifliamir@fmipa.unp.ac.id* Doi: https://doi.org/10.24036/invotek.v21i3.928

Abstract

One of the important factors for living things and also the weather element is soil moisture. Observations of weather elements have been carried out used according to future needs. Soil moisture has been using to manage weather forecasts, early warning of drought, water resources, and irrigation scheduling. Due to the development of sensors in the electronics world, various digital measuring instruments where is founded to make it easier to measure soil moisture. This article describes the manufacture of a soil moisture meter and the results of the performance specifications of the humidity measurement system with the internet of things-based SHT11 sensor. This instrument uses an SHT11 sensor is used for the humidity sensor and soil temperature, Nodemcu ESP8266 is used as Internet access to transmit to thingspeak, data save in the micro SD memory.

Keywords: Instruments, Soil moisture, SHT11, Internet of Things, ThingSpeak

1. Introduction

Soil moisture is one of the elements of weather. Observations of weather elements carried out to using according to future needs. Soil moisture was using to manage weather forecasts, early warning of drought, water resources, and irrigation scheduling. Agriculture is one of the supporting factors for the national economy in an agricultural country like Indonesia, namely as a provider of housing, clothing, and food for the population, as well as a source of foreign exchange from non-oil and gas exports.[1]. Agricultural food production is influenced by climate. Climate change was associated with an increase in greenhouse gases which in turn will affect crop yields which are influenced by changes in climatic parameters such as temperature, humidity, and levels of carbon dioxide in the air.[2].

Previously, several studies to carry out regarding internet of things-based measuring instruments, including a colorimeter built with a light detector using the OPT101 sensor [3], designed a colorimeter used to detect food coloring using a photodiode sensor [4], a tool for measuring air pressure with a smartphone display using the DT-Sense Barometric Pressure [5], a tool for measuring air pressure with a smartphone display using the DT-Sense Barometric Pressure [6]. Based on previous research, Internet of Things-based measuring instruments have been designed but the data can only be stored on smartphones. Therefore, this research will design a tool entitled "Making Soil Moisture Measurement Using the SHT11 Sensor Based on the Internet of Things" where the data can be accessed anytime and anywhere, using an SD Card with power in the form of state electricity company and a battery.

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2. Method

BMKG, Sicincin, West Sumatra is the place to research this soil moisture measuring instrument. SHT11 is a temperature and humidity sensor with a 14 bit analog to digital converter and input and output controllers [7]. The size is very small (2x4 mm^2), so it is very practical in various applications. The SHT11 humidity accuracy is ± 3.0% RH, and the temperature accuracy is 0.4ºC. The physical form of the SHT11 sensor is shown in Figure 1. SHT11 has 4 legs that have their respective functions on each leg. The SHT11 sensor foot configuration can be shown in Table 1.

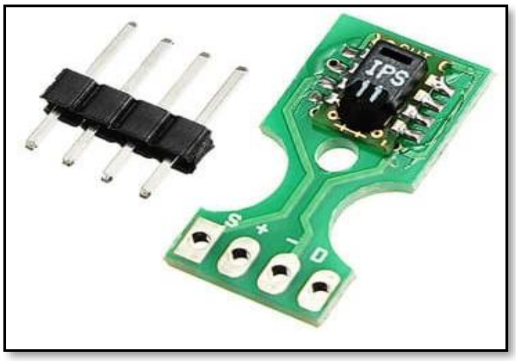

Figure 1. SHT11 Sensor

Table 1. SHT11 Sensor Foot Configuration

Pin Symbol	Pin Name	Information
-	GND	*Ground*
+	VDD	*Supply* 2.4 – 5.5 V
D	DATA	*Serial Data Bidirectional*
S	SCK	*Serial Clock Input*

Android smartphone is a cellphone with almost the same function as a computer. Smartphones are phones that can provide other advanced functions such as e-mail, internet, etc. Therefore, a smartphone can be said to be a microcomputer with a telephone function. Software development will be primarily in the development of mobile devices, because most people who use computers will indirectly use smartphones. Arduino uno is a microcontroller board based on ATmega328. This microcontroller consists of a USB connection, 6 analog inputs, a 16 MHz crystal oscillator, a digital input / output with 14 pins (some of which are used as a reset button, a voltage source connector, an output and an ICSP header. Nodemcu is a board developed from IoT products. The internet of things is built with wireless radio waves that allow different devices to communicate with one another via the internet. This platform includes several standards such as wi-fi, bluetooth low power. Physical objects on the internet of things collect and process data it can receive from the environment[8]. ESP8266 is a board with various features such as microcontroller, USB to serial communication chip, wifi chip, and wifi access capability.

App Inventor is an IDE in the form of an application as a display on Android that can be easily used, cloud-based in the form of codes (click and drag puzzles). Block programming is shown in Figure 2. To better understand the design of the tool path from the beginning to the end of the system block diagram is shown in Figure 3. SHT11 is a sensor for measuring humidity and temperature. This sensor is connected to the Arduino Uno which is then connected to the Node MCU microcontroller. The SHT11 sensor is programmed in a programming language, namely arduino, then stored on arduino uno which is then sent to the Nodemcu microcontroller. In programming there are also programs that are useful so that you can connect to wifi. If it is connected, then the data is sent to the server, which is what is used here is thing speak. After that using the Inventor app programming the data is taken and displayed on the android smartphone.

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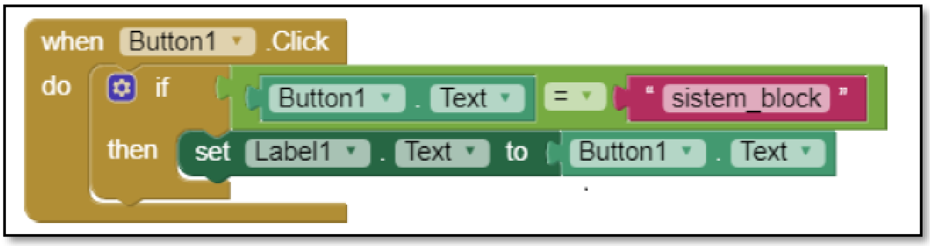

Figure 2. App Inventor Program Block

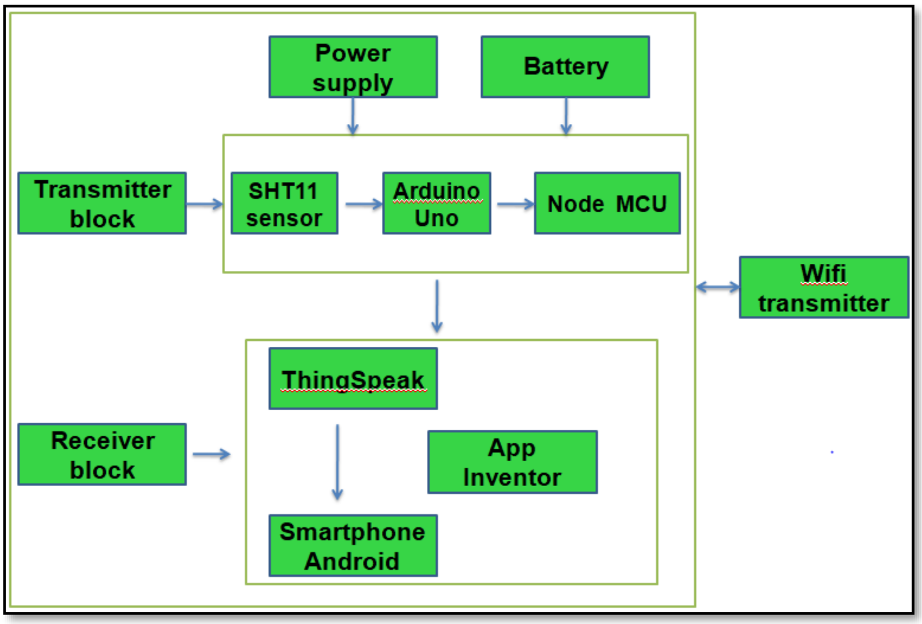

Figure 3. System Block Diagram

The use of digital measuring instruments is more practical and saves time when measuring[9]. Wireless or cordless telemetry has advantages, among others, that it does not require a lot of money compared to using a cable. So that it can be more practical and efficient to use a wireless system in measurement because the user does not need to be close to the device in order to obtain the data needed, so that it can be observed from a distance.[10].

This soil moisture meter is designed with a small box for the place of the circuit, the Nodemcu microcontroller and the sensor of the measuring instrument. Where this tool will be placed at a depth of each, which is 20 cm according to the depth of the tool on the BMKG. The measuring instrument is designed so that data can appear on an android smartphone. The design of the tool is shown in Figure 4.

In addition to the mechanical design, the electronic components that will be used later must also be designed so that the humidity meter can be achieved according to the desired goal. The series of humidity measuring instruments is shown in Figure 5.

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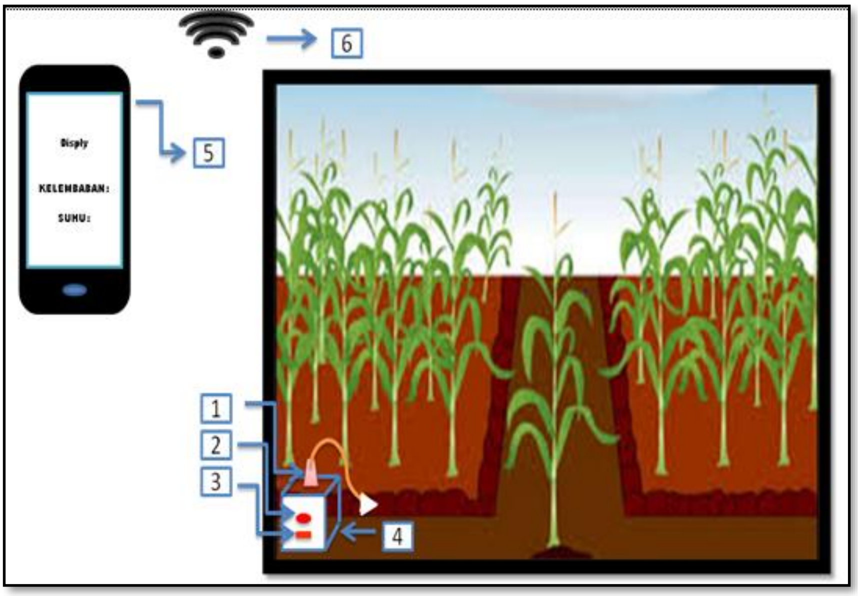

Figure 4. Hardware Design

Information:
1. SHT11 Sensor
2. On / Off button
3. Reset button
4. Measuring tool builder circuit box
5. Android smartphone to display measurement data
6. Wi-fi to transmit a signal so that the microcontroller and android smartphone are connected to the internet

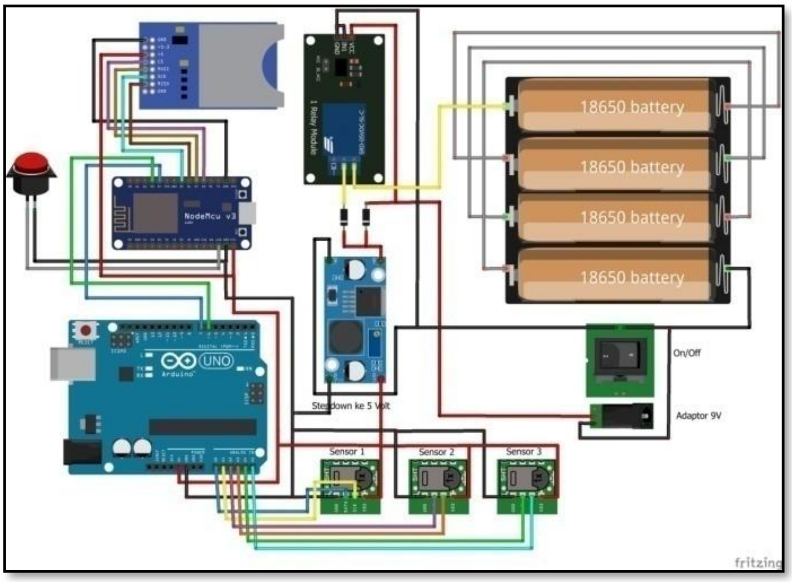

Figure 5. Electronic Circuit Forms

Based on Figure 5, it can be seen that several electronic components where the program on the SHT11 sensor will be inputted to Arduino which will then be sent to Nodemcu ESP8266 so that the sensor reading data can be read later on an Android smartphone. In addition to readings on an android smartphone, sensor data will also be stored on the memory card. In the picture you can see there are two sources for turning on the device, namely PLN and also the battery, where if a power cut occurs, the source will automatically change to the battery with the help of a relay.

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Design software using the Arduino IDE. The first step is to connect the Nodemcu board to an existing wifi transmitter (WLAN). For the first time the wifi transmitter that will be used first declare the SSID and password then proceed to connect. If the board is not connected, the process will start again from the beginning until it is connected and if it is connected to a wifi transmitter this board can access the internet then the sensor data can be read on the board and the data is sent to the internet, namely Thingspeak. On Thingspeak the data appears in graphical form in real time. The flow diagram is shown in Figure 6.

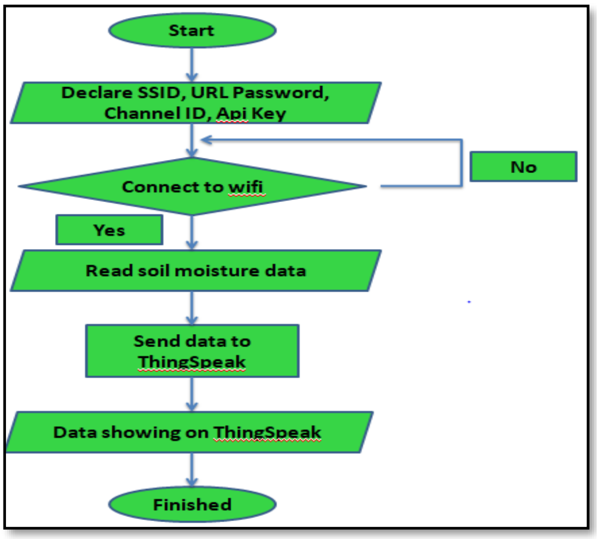

Figure 6. Arduino Software Design

Figure 6 shows the software design using the Inventor app. The first time that is done is inputting the url from thingspeak as a server. Then the data obtained by thingspeak will be defined in the inventor app. Furthermore, soil moisture data can appear on an android smartphone. There are 2 options after that, whether to continue to the humidity chart or return to the initial view of the program, the graph that is displayed is a real time chart. The flow chart is shown in Figure 7.

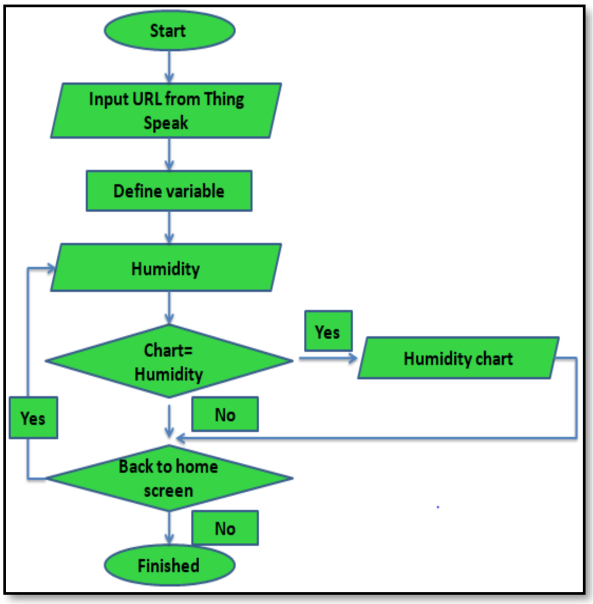

Figure 7. Design Software on the App Inventor

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3. Results and Discussion

3.1. Specifications of Soil Moisture Measurement Tool with IoT-Based SHT11 Sensor

Instrument performance specifications are the components of the measuring instrument and the function of each component of the measuring instrument. This gauge is designed to monitor the moisture of agricultural soil. The system builder electronic circuit is designed in such a way that it becomes a good measuring tool to use. This electronic circuit is placed in a space called a circuit box. The series box is made of acrylic which has a size of 9x9x6 cm with a thickness of 0.3 cm of acrylic. The series box is shown in Figure 8.

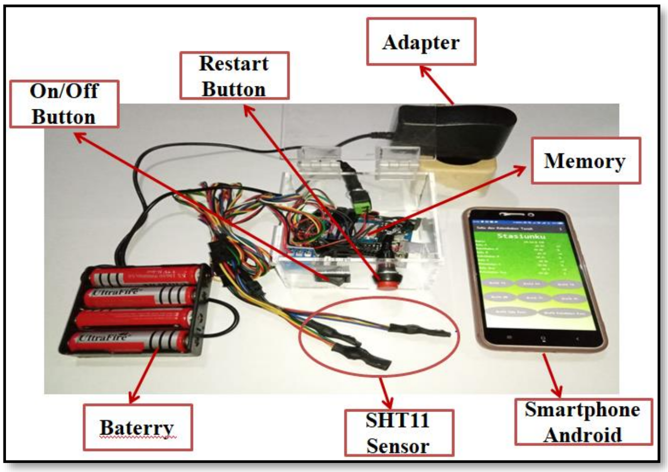

Figure 8. Soil Moisture Measurement Tool

This measuring instrument consists of a series of boxes containing several constituents including the input system and transmitter. The inputs include an on / off switch and a reset button. The transmitter consists of a SHT11 sensor and a nodemcu and arduino uno microcontroller. If the measuring instrument is connected to a voltage source, the on / off button on the measuring instrument can turn the measuring instrument on and off. The on / off switch is an indispensable circuit in a circuit. The reset button circuit is also a mandatory series on the measuring instrument. The reset button circuit will be very useful when the measuring instrument is experiencing an error or cannot work normally, the reset button can return the measuring instrument to its original state.

The circuit maker of the measuring instrument is equipped with an adapter and a battery as a power supply circuit for the measuring instrument. The adapter is used because the microcontroller is very sensitive, so that if the current flowing to the microcontroller is unstable, the microcontroller will not function properly and the microcontroller will become hot. The battery is used when the adapter cannot be used, such as in the event of a power cut, the power supply is automatically changed to the battery.

The microcontroller functions as the brain of the measuring instrument and can send data received from the sensor to the Android smartphone. The microcontroller used is the Nodemcu ESP8266, but before going to Nodemcu the sensor data is sent first to Arduino Uno. Nodemcu ESP8266 is a microcontroller that uses a wifi module so that it can access the internet. The Nodemcu ESP8266 has one analog pin and nine digital pins. This microcontroller is programmed with Arduino IDE so that it can be connected to a local wifi transmitter (WLAN). Then the data obtained will be sent from Nodemcu ESP8266 to the thingspeak server. Data can be retrieved on an android smartphone as shown in Figure 9.

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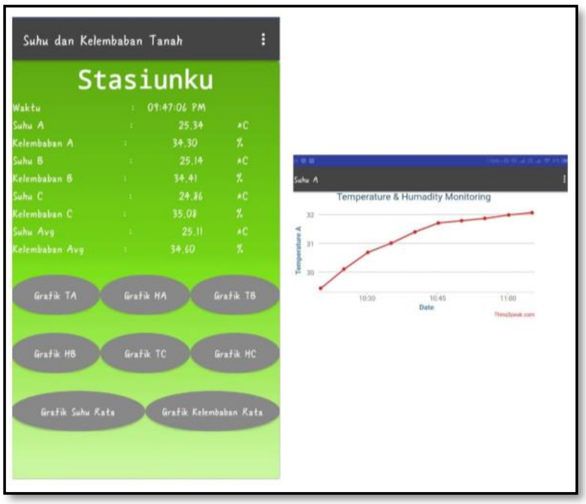

Figure 9. Measuring Instrument Interface

3.2. Sensor Testing

SHT11 sensor characterization was carried out to see the effect of humidity on time and weather at the time of data collection. To find out the characteristics of the SHT11 sensor, measurements were made at different heights. As for based on observations of sensor output is shown in Table 2.

Table 2. SHT11 Sensor Testing

Time		**Humidity**		**Humidity**
10.30		80.77		77.93
10.35		80.32		77.93
10.40		80.77		77.44
10.45		80.26		76.95
10.50		80.75		76.47
10.55		80.73		76.95
11.00	**First Altitude Test**	80.29	**Second Altitude Test**	76.48
11.05		80.32		76.96
11.10		79.85		77.94
11.15		80.32		77.47
11.20		79.87		77.47
11.25		79.86		77.97
11.30		78.47		77.49
11.35		77.99		77.48
11.40		77.51		76.59

Based on measurements in the first altitude test and the second altitude test which was carried out from 10.30 to 11.40, the humidity results were obtained which decreased with increasing temperature at that time. Where the weather at that time was getting hotter and warmer so that the temperature increased which resulted in the humidity falling from time to time. However, there are times that have experienced a decline and increase due to the sometimes changing weather. The decrease in humidity occurs because when the weather is hot the water content in the air will decrease. Graph of change in humidity can be seen in Figure 10.

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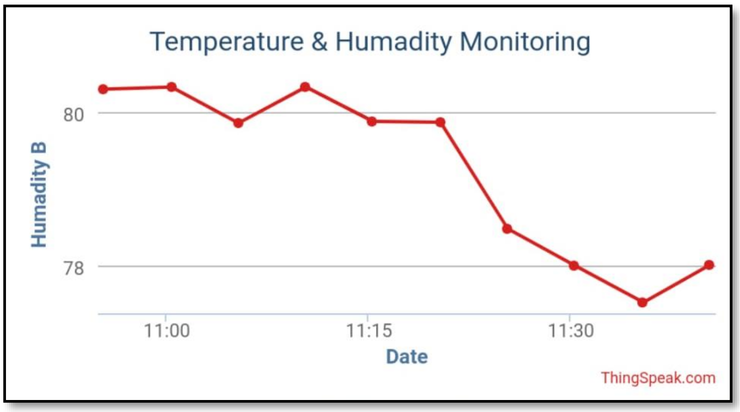

Figure 10. Moisture Testing Graph

In Figure 10 is a reading that is read by thingspeak where humidity has decreased from time to time according to the weather and temperature at the time of data collection.

3.3. Accuracy of Soil Moisture Measuring Instruments

In measuring soil moisture with a depth of 20 cm, the error percentage of the measuring instrument ranges from 2% to 2.8%. While the accuracy ranges from 97.28% to 97.92% with an average percentage of accuracy is 97.71%. Graph of comparison of soil moisture measurement for proposed instruments and standard measuring instruments as in Figure 11.

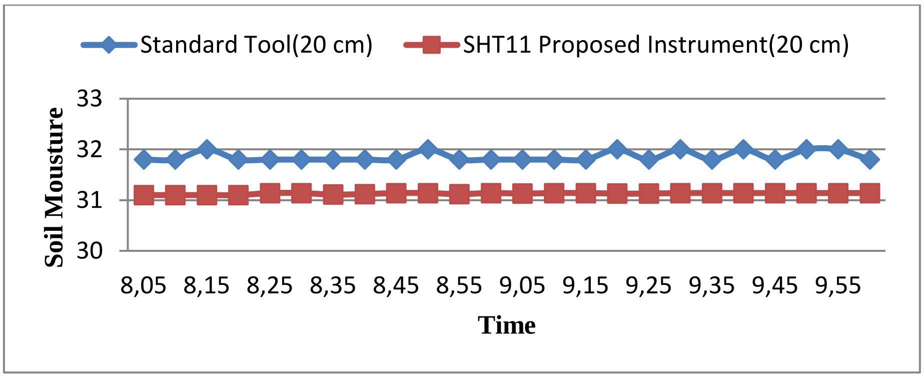

Figure 11. Comparison Chart of Soil Moisture with a Depth of 20 cm

In the measurement of soil moisture the accuracy average is 99.95%. The accuracy of measuring soil moisture can be seen in Table 3. Error, accuracy and accuracy data obtained from statistical calculations, this measuring instrument is suitable for use and meets standards. This measuring tool can be used in laboratories, BMKG and as a reference in observing weather parameters. As a comparison of the results on SHT11 used a standard tool in the form of a soil moisture tool. The accuracy of measuring soil moisture is shown in Table 3.

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Table 3. Accuracy of Measurement of Soil Moisture Depth of 20 cm

Time	Soil moisture		Average (Proposed instrument)	Percentage of Accuracy (%)	ΔX (Repeated measurement uncertainty)	Relative Error(%)
	Standard Tools	Proposed instrument				
8.05	31.8	31.1	31.12	99.939	0.0075	0.024
8.10	31.8	31.1		99.939		0.024
8.15	32	31.1		99.939		0.024
8.20	31.8	31.1		99.939		0.024
8.25	31.8	31.14		99.933		0.024
8.30	31.8	31.14		99.933		0.024
8.35	31.8	31.11		99.971		0.024
8.40	31.8	31.12		99.997		0.024
8.45	31.8	31.14		99.933		0.024
8.50	32	31.14		99.933		0.024
Average Percentage of Accuracy				**99.95%**		

4. Conclusion

This research build a soil moisture measuring instrument based on the Internet of Things. The performance specifications of the humidity meter consist of a measuring instrument box that is attached to the measuring instrument's electronic circuit. The measuring instrument builder circuit consists of a SHT11 sensor, a NodeMCU ESP8266 microcontroller, arduino Uno, an on /off button and a reset button, SDcard. Humidity measurement results are displayed on the android smartphone. The SHT11 sensor measures soil moisture, and is processed by arduino Uno which is then sent to the ESP8266 MCU Node. The data is then sent to the ThingSpeak server which will then appear on the android smartphone.

Based on the results of the data obtained from the measurement, the design specification of the measuring instrument with the accuracy of measuring soil moisture by the measuring instrument is 97.534%. The average accuracy in measuring soil moisture is 99.95%.

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References

[1] A. A.-J. L. P. 2006-203. 190. 37. 4. A Adimihardja - Jurnal Litbang Pertanian, 2006 - 203.190.37.42, “Strategi mempertahankan multifungsi pertanian di Indonesia,” vol. 25, no. 98, pp. 99–105, 2006, [Online]. Available: http://203.190.37.42/publikasi/p3253064.pdf.

[2] M. L. Parry, C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fischer, “Effects of climate change on global food production under SRES emissions and socio-economic scenarios,” *Glob. Environ. Chang.*, vol. 14, no. 1, pp. 53–67, 2004, doi: 10.1016/j.gloenvcha.2003.10.008.

[3] H. Putra and Y. Yulkifli, “Studi Awal Rancang Bangun Colorimeter Menggunakan Sensor Opt101 Berbasis Sistem Android Dengan Display Smartphone,” *Komun. Fis. Indones.*, vol. 16, no. 2, p. 155, 2019, doi: 10.31258/jkfi.16.2.155-162.

P-ISSN: 1411-3414
E-ISSN: 2549-9815

[4] Yulkifli, D. A. Wulandari, R. Ramli, S. B. Etika, and C. Imawan, “A simple colorimeter based on microcontrollers to detect food dyes,” *J. Phys. Conf. Ser.*, vol. 1528, no. 1, 2020, doi: 10.1088/1742-6596/1528/1/012066.

[5] I. Tri Handini, Y. Yulkifi, and Y. Darvina, “Rancang Bangun Sistem Pengukuran Tekanan Udara Menggunakan DT-Sense Barometric Pressure Berbasis Internet of Things dengan Display Smartphone,” *J. Teor. dan Apl. Fis.*, vol. 8, no. 1, pp. 1–10, 2020, doi: 10.23960/jtaf.v8i1.2257.

[6] M. Iqbal and Y. Darvina, “Rancang Bangun Sistem Pengukuran Suhu Dan Kelembaban Udara Menggunakan Sensor Sht75 Berbasis Internet of Things Dengan Display Smartphone,” *Ranc. Bangun Sist. Pengukuran Suhu Dan Kelembaban Udar. Menggunakan Sens. Sht75 Berbas. Internet Things Dengan Disp. Smartphone*, vol. 22, no. 3, pp. 97–104, 2019.

[7] A. B. Putranto, B. I. Laksono, and B. Nurdiyanto, “Aplikasi Sensor Sht11 Pada Pengukuran Suhu Tanah,” *J. Meteorol. dan Geofis.*, vol. 10, no. 1, pp. 66–72, 2009, doi: 10.31172/jmg.v10i1.34.

[8] L. Atzori, A. Iera, and G. Morabito, “The Internet of Things: A survey,” *Comput. Networks*, vol. 54, no. 15, pp. 2787–2805, 2010, doi: 10.1016/j.comnet.2010.05.010.

[9] Yulkifli, Z. Afandi, and Yohandri, “Development of Gravity Acceleration Measurement Using Simple Harmonic Motion Pendulum Method Based on Digital Technology and Photogate Sensor,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 335, no. 1, 2018, doi: 10.1088/1757-899X/335/1/012064.

[10] Y. Yulkifli, Y. Yohandri, and Z. Affandi, “Pembuatan Sistem Pengiriman Data Menggunakan Telemetri Wireless untuk Detektor Getaran Mesin Dengan Sensor Fluxgate,” *Setrum Sist. Kendali-Tenaga-elektronika-telekomunikasi-komputer*, vol. 5, no. 2, p. 57, 2016, doi: 10.36055/setrum.v5i2.813.