Implementation of Remote Groundwater Filter With ESP32 based on Internet of Things

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Abstract: Conventional water filters available in the market cannot measure water quality, detect filter condition, automatically backwash when the filter is dirty and cannot be monitored anywhere. Therefore, by using ESP32, the filter condition can be determined and backwash if needed. From the existing problems, it is necessary to implement a control system and monitor the condition of the water filter, with the program features on the microcontroller and the web display used to control and monitor the tool, as well as internet of things-based testing and measurement of the tools made. From the research conducted, all sensors work well and the web display displays data in realtime so that it can support the performance of the tool to work as desired both automatically and manually.

Keyword: ESP32, water filter, water quality, ackwash, monitoring, , internet of things, realtime.

INTRODUCTION

Groundwater is water that is in the layer inside the surface layer of the soil. Groundwater is often used by the community to meet their daily water needs, which are usually obtained from wells. Nowadays, the quality of groundwater has decreased, some are yellow, cloudy, to the smell of iron. According to research conducted in 2021 by (Komarudin.D, Hidayat.F, Kurniayu P.D, 2021), that groundwater in Bekasi City has heavy metal content exceeding the threshold set by the government. Household waste and industrial waste are sources of groundwater pollution (Putra, N. C., Jayanta, & Widiastiwi, Y, 2020). Filtration is one of the water treatment techniques, with the technique of separating substances mixed with water using filter media. The use of water filters is very helpful in getting clean water that meets the standards of clean water for use. For living things on this earth, water is a very important source of life (Fatimura, M, Bakrie M, Wahyudi A, Safentry A.,2019) . So a water filter is needed to get clean water that meets the standards (Supriya, L. C., & Gayathri, S., 2018), (Erfianto, B., & Putrada, A. G., 2019).

Water filters require maintenance in the form of checking conditions, cleaning, and replacing filter media regularly so that they can work optimally at all times. In this modern era, people tend to want things that are easy and fast. Manual water filter maintenance in addition to

draining time is also difficult to do by laymen. Therefore, automation is needed to make it easier to maintain water filters, but similar products are not yet on the market.

From the above problems, the need for an automatic water filter is important and urgent. The research we conducted related to water filter control with the title "IMPLEMENTATION REMOTE GROUND WATER FILTER WITH ESP32 BASE ON INTERNET OF THINGS" with intelligent water filter control, the problem of checking the effectiveness of the filter can be monitored easily. Water filter cleaning can also be done automatically with the Backwash mechanism. Pumping water in reverse through the filter is called backwash (Supriya, L. C., & Gayathri, S., 2018). It can also provide information on the amount of water that has been filtered and filter replacement alerts.

METHODS

The data analysis technique used in this study can be described as follows:
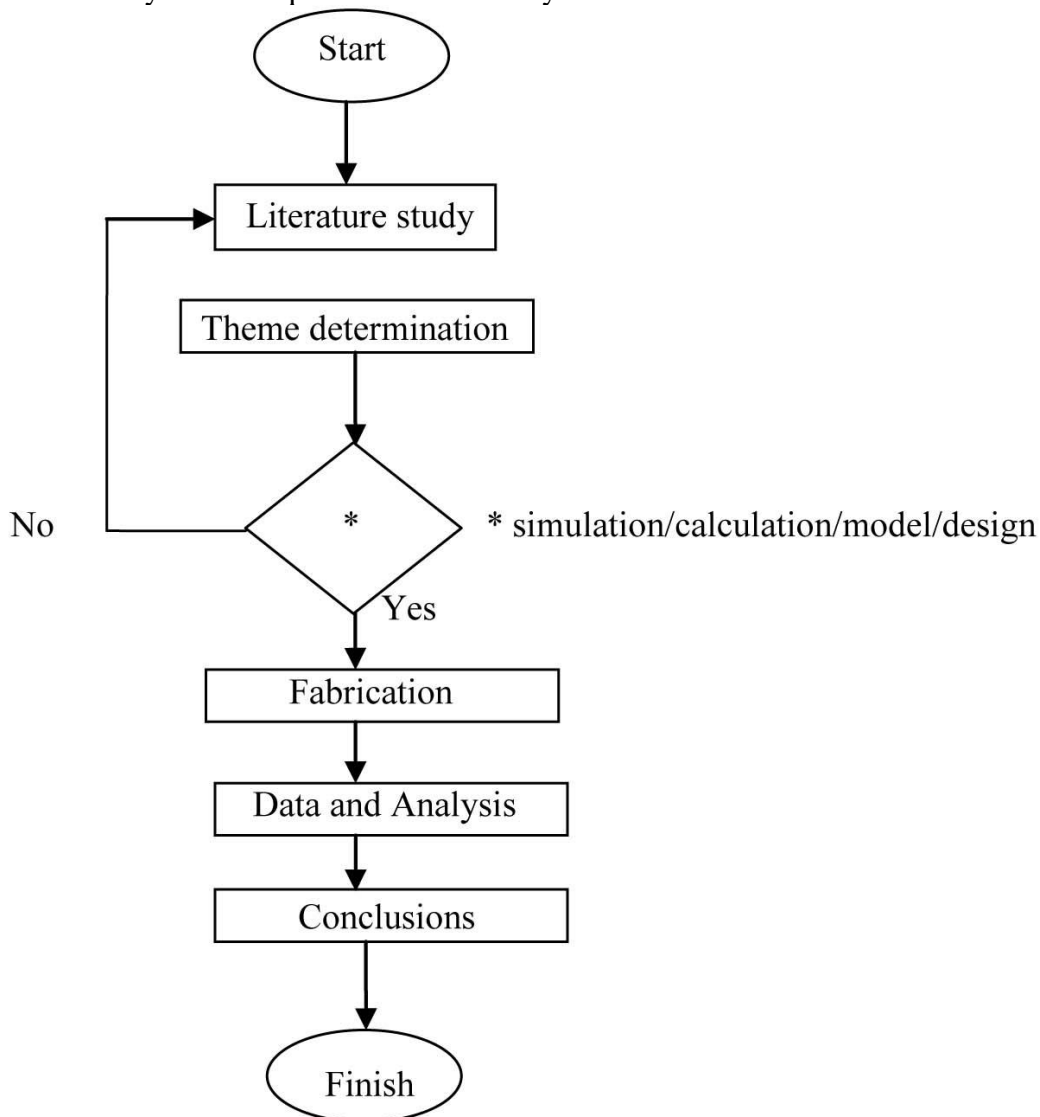

Figure 1. Research flow chart

In Figure 1, the research method carried out is a literature study and assembly of tools and components to design the tool from the prototype. The research conducted by the author focuses on the water filter monitoring and automation system. If there is a failure in the system or design made then return to the literature for troubleshooting.

IMPLEMENTATION METHOD

The implementation requires a diagram that serves to make it easier to understand the workflow of the system. The following is a diagram of the implementation of the tool made
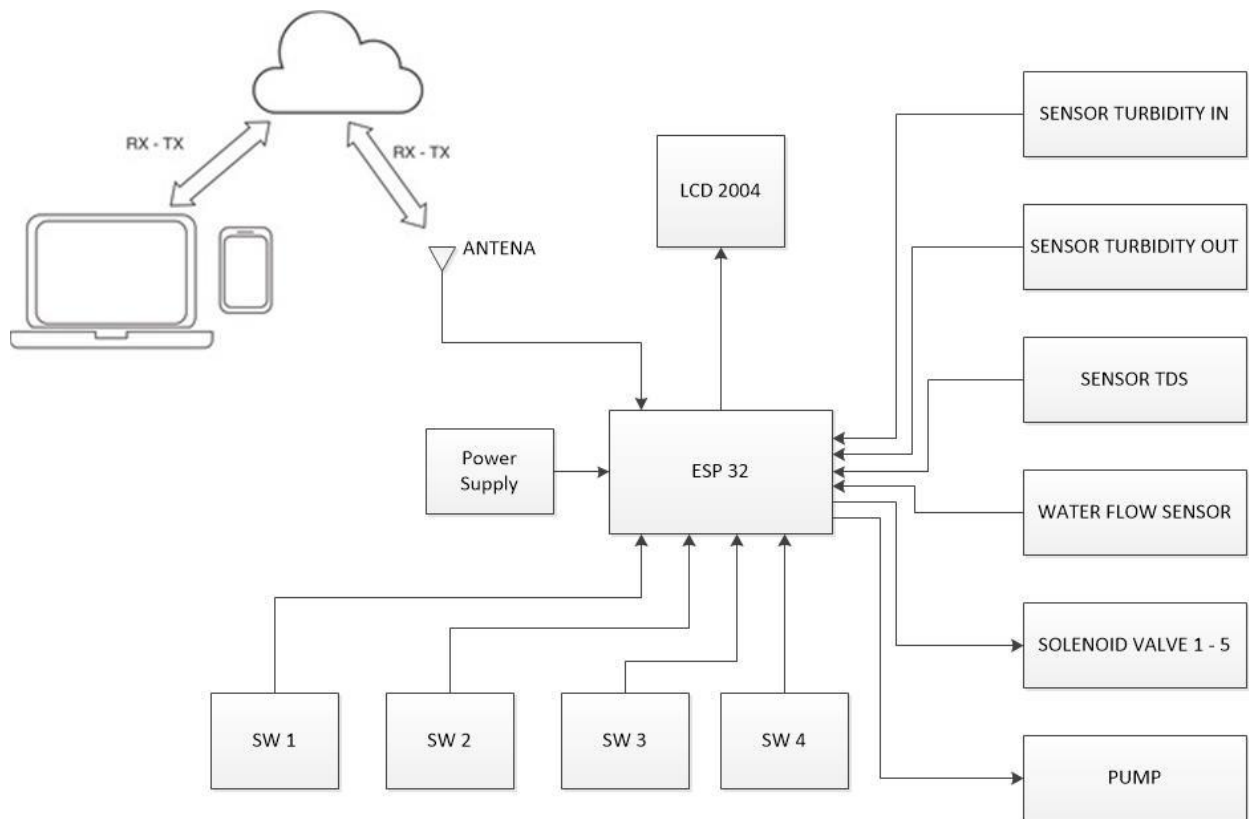

Figure 11 Block diagram of implementation

Figure 11 is a block diagram of this experimental system. This experiment will use several input and output sensors using a solenoid valve. And also the tools in this study will be able to connect to the cloud and can be monitored via laptop or cellphone.
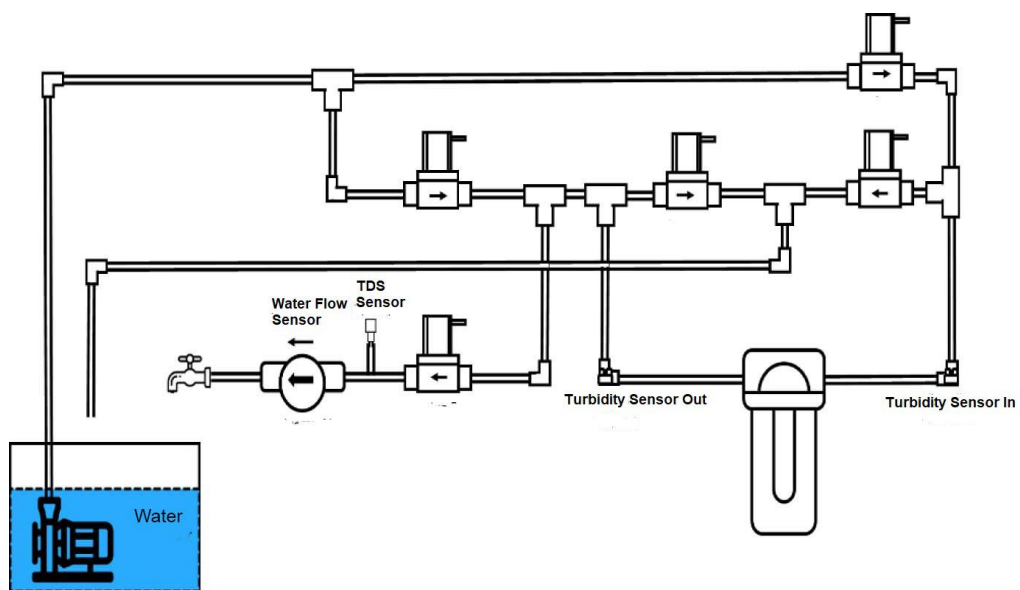

Figure 12. Piping

Figure 12 is a picture of the piping on the water filter. There is a water turbidity sensor that will detect water quality before filtering and after filtering. The TDS sensor is also used to assess the quality of the water output. In the diagram there is also a water flow meter to determine the discharge of water that comes out. The water flow is controlled by 5 electronic valves that will determine the operation of the filter.

Table 2 Water filter operation

Operation	Valve 1	Valve 2	Valve 3	Valve 4	Valve 5
Normal	**ON (open)**	OFF(close)	OFF/close	OFF(close)	**ON (open)**
Backwash	OFF(close)	**ON (open)**	OFF/close	**ON (open)**	OFF(close)
Clean	**ON (open)**	OFF(close)	**ON(open)**	OFF(close)	OFF(close)
Stop	OFF (close)	OFF(close)	OFF/close	OFF(close)	OFF(close)

There are 4 operations on the system, namely: Normal, Backwash, Clean, and Stop. More details about the water filter operation can be seen in table 2.
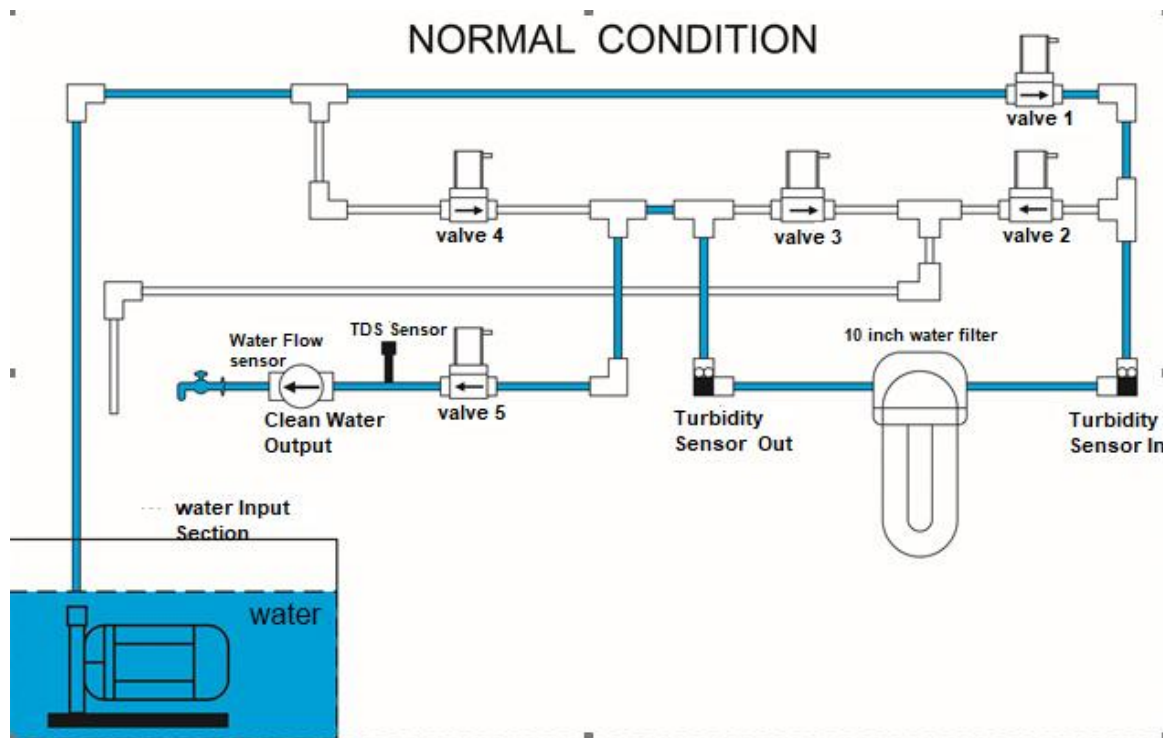

Figure 13. Normal system operation

Figure 13 is the water flow under normal operating conditions. Condition Valve 1 and valve 5 are in open condition. Valve 2, valve 3 and valve 4 are in closed condition.
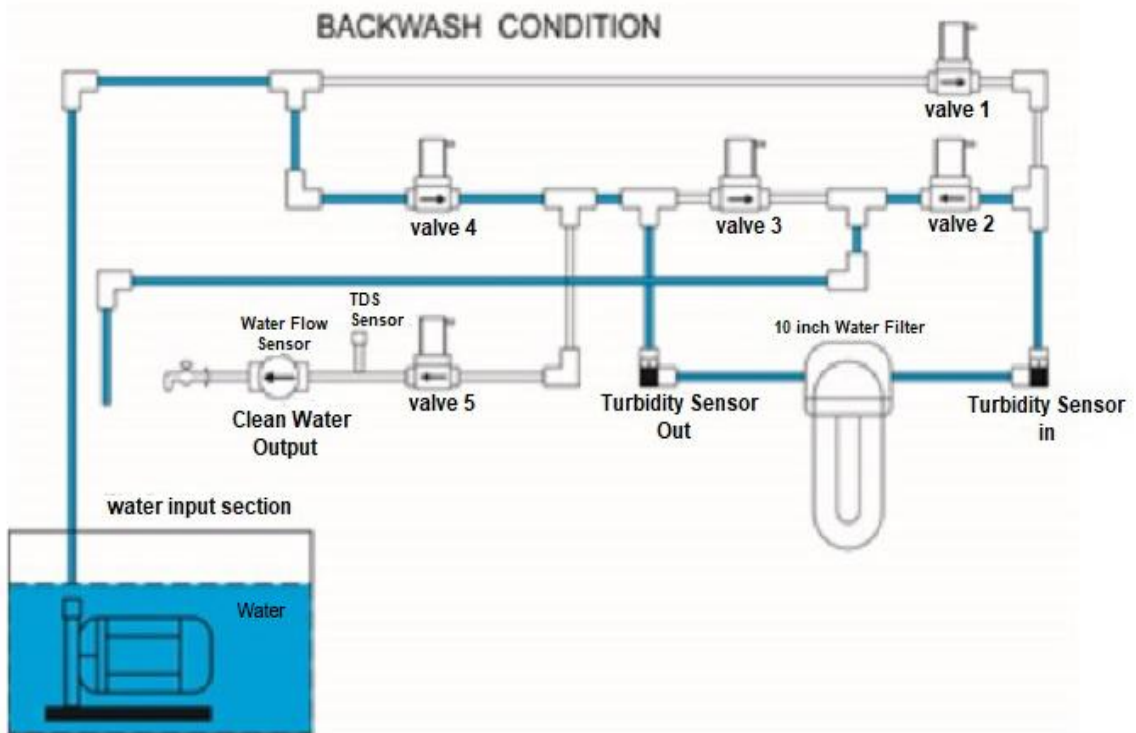
Figure 14. Backwash system operation

Figure 14 is the water flow in the backwash operating condition. Valve 4 and valve 2 are in open condition. Valve 1, valve 3 and valve 5 are in closed condition.
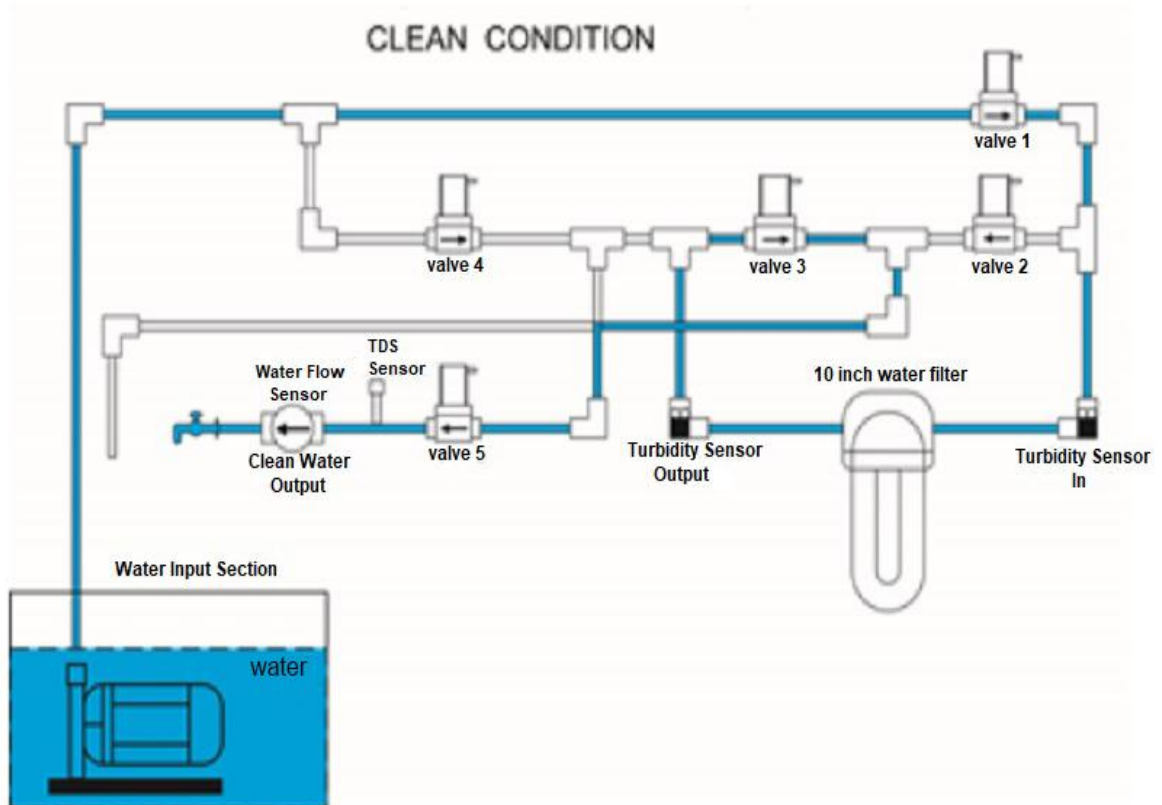

Figure 15. Clean system operation

Figure 15 is the water flow in the Clean operating condition. Valve 1 and valve 3 are in open condition. Valve 2, valve 4 and valve 5 are in closed condition.
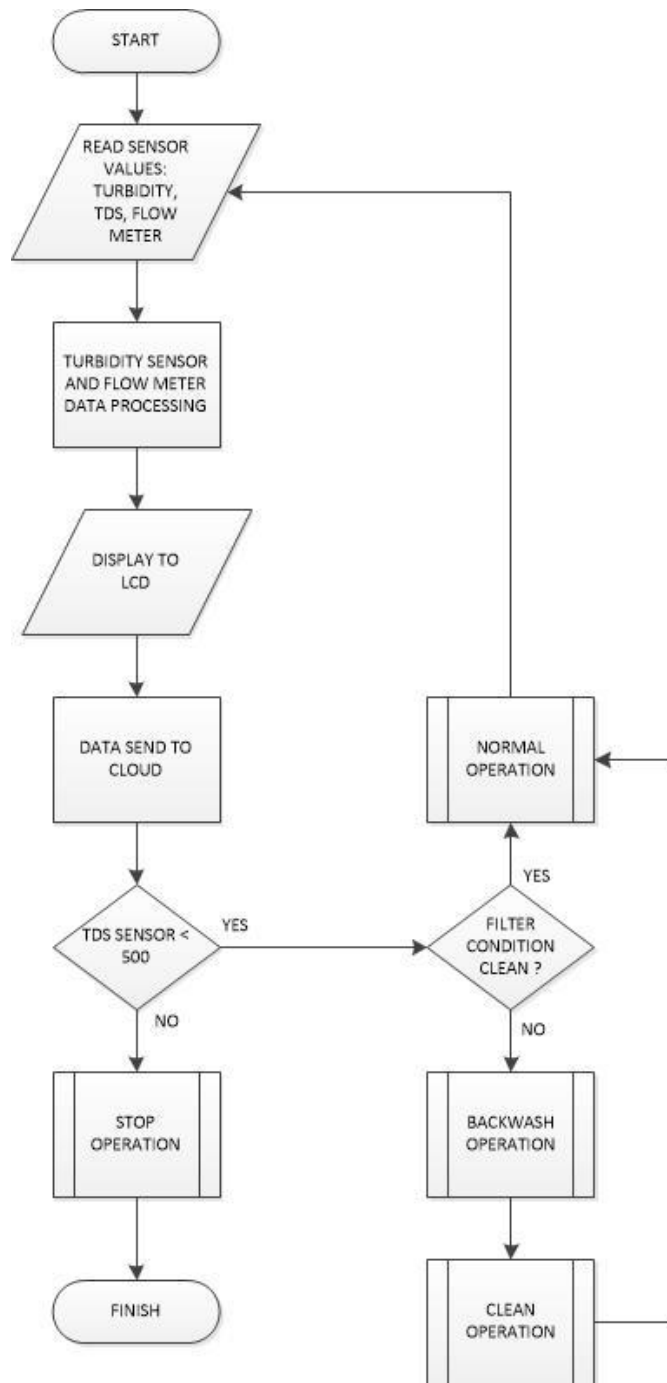

Figure 16. Flow chart Diagram Systems

The working system of this tool is in accordance with the flow chart in Figure 16. The microcontroller will read the sensor values (turbidity, TDS, and Flow sensor) then will display the data on the LCD and IoT web dashboard, the system will automatically backwash if the TDS sensor value is less than 500 and the filter condition is dirty with an indication of a small flow meter value reading below 3 litres / minute. After the tool performs the backwash operation, the system will proceed to the clean operation before returning to normal operation. In addition to automatically this tool can also be done manually selecting the operating system by controlling through the IoT web dashboard or control panel.

RESULT AND DISCUSSION
A. Hardware Result and Discussion
The prototype implementation of the tool is shown in Figure 17:

Figure 17. View of the prototype system

Making hardware prototype using a common 10 inch water filter on the market which is connected to the solenoid and sensor using ½ inch pipe.

Figure 18. Information display on LCD

Information description on the LCD in Figure 18 is as follows:
Tur_IN is the Turbidity Value before entering the water filter, the unit value is NTU (Nephelometric Turbidity Unit).
Tur_OUT is the Turbidity Value before after exiting the filter, the unit value is NTU (Nephelometric Turbidity Unit).
TDS is the value of the TDS sensor with the unit is ppm (Part Per Million).
Flw is the value of the water discharge that flows in the output pipe.
T is the total water that has been filtered.
P is the condition of the pump ON or OFF.
M is the running operation mode NLR (Normal), BckW (Backwash), Clan (Clean), Stop (Stop).

Sensor characteristics

In this study using 3 types of sensors namely Turbidity sensor, TDS sensor, and Flow Meter sensor with the following characteristics:

1.*Turbidity sensor*

By conducting tests and measurements using a Tektronix TBS1102 oscilloscope 5 times with 2 water samples, namely clear water and turbid water and obtained the following results:

Table 3. Turbidity measurement results of clear water sensor

No.	measured voltage (Volt)	turbidity value on the device (NTU)
1	2,92	0
2	2,93	0
3	2,93	0
4	2,92	0
5	2,92	0

Table 4. Turbidity measurement result of turbid water sensor

No.	measured voltage (Volt)	turbidity value on the device (NTU)
1	0,92	3000
2	0,90	3000
3	0,90	3000
4	0,93	3000
5	0,92	3000

Table 3 and table 4 are the measurement results of the turbidity sensor which initially before being put into the water is 2.42 V. Then when the sensor is inserted into clear water, get results as in table 4.1 and when the sensor is inserted into turbid water, get results as in table 4.

In the process of testing the turbidity value, there are differences in measurement values by comparing the measurement results of the turbidity sensor with a reading accuracy of $+10\%$, then from the measurement results get an average sensor output voltage reading of 2.92 V in clear water and 0.91 V in turbid water. And also the measurement results get an average reading of the static NTU value which is 0 NTU for clear water and 3000 NTU for turbid water.

2.TDS sensor

By conducting tests and measurements using the HIOKI DT4212 multimeter measuring instrument and the XMTDS01YM water solute level measuring instrument 5 times with 2 water samples, namely clear and turbid water, the following results were obtained:

Table 5. Clear water sensor TDS measurement results

No.	measured voltage (V)	TDS value on the device (ppm)	TDS value measuring device XMTDS01YM (ppm)	Difference	*Error* (%)
1	0,32	128	123	5	4,06
2	0,31	123	122	1	0,81
3	0,32	130	123	7	5,69
4	0,31	126	123	3	2,43
5	0,32	131	123	8	6,50

Table 6. TDS measurement results of turbid water sensor

No.	measured voltage (V)	TDS value on the device (ppm)	TDS value measuring device XMTDS01YM (ppm)	Difference	Error (%)
1	0,48	189	195	8	4,54
2	0,47	181	194	13	5,11
3	0,47	183	194	13	5,05
4	0,48	192	195	6	3,37
5	0,48	193	195	4	2,25

3.*Flow meter sensor*

By testing and measuring the frequency and voltage of the HIOKI DT4212 multimeter 5 times with the condition of the device not operating and operating, the following results were obtained:

Table 7. Measurement results of flow meter sensor when the device is not operating

No.	Voltage (V)	Frequency (Hz)	Water flow (m³/s)
1	4,0	24,5	0,09
2	3,9	25,5	0,0
3	4,0	25,2	0,0
4	4,0	24,7	0,09
5	4,1	24,3	0,09

Table 8. Measurement results of flow meter sensor operation

No.	Voltage (V)	Frequency (Hz)	Water flow (m³/s)
1	2,0	27,1	5,00
2	2,1	26,8	6,19
3	2,1	27,3	6,02
4	2,0	27,3	5,00
5	2,0	27,6	5,42

In the process of testing the voltage and frequency values, there are differences in measurement values by comparing the measurement results of the flow meter sensor with a reading accuracy of + 10%, then from the measurement results get an average sensor output voltage reading of 2.04V when the device is not operating and 4V when the device is operating. And also the measurement results get an average frequency value reading of 24.84 Hz when the device is not operating and 27.22 Hz when the device is operating, and get an average water discharge reading of 0.05 (m³/s) when the device is not operating and 5.52 (m³/s) when the device is operating.

B. Software Results and Discussion
**   - Compile the program with Arduino IDE**
For Turbidity and TDS sensor readings using the ADC interface. By reading the voltage value on each sensor and calculating with the existing equation, the Turbidity and TDS values

will be generated. For example, if the Turbidity voltage is 4.2 Volts, using equation 1, the result is 0.904 NTU. And the TDS voltage is 0.5 Volts, using equation 3 to get the result of 190 ppm.

For Flow Meter to find water discharge by calculating the pulse generated by the sensor every second. By calculating using equation 4 to get water discharge as an example of a pulse that is read is 800 then the water discharge is 1.78 liters / second.

Figure 18. Program display in Arduino IDE

In Figure 18, the WiFi address used is entered including the password and the parameters displayed on the IoT web dashboard such as water quality conditions, and the accumulation of filtered water. Periodic transmissions are also prepared to monitor the condition of the water filter in real-time.

-Response Time of Solenoid Valve

Table 9. Testing solenoid valve response time

No	Item	Time (mili second)					Means (mili second)
		1	2	3	4	5	
1	Normal to Backwash	480	700	630	550	630	**598**
2	Backwash to Clean	760	680	420	640	780	**656**
3	Clean to Normal	800	800	880	850	510	**768**
4	Normal to Stop	550	590	640	660	480	**584**
5	Stop to Start	680	940	490	630	810	**710**

Normal, backwash, clean and stop operations are selected based on the results of the water quality sensor readings by activating and deactivating the solenoid valve. To find out the time required to switch for each operation, an experiment was conducted with the results in table 9. From the data in table 9 it can be concluded that to change the operation takes less than

1 second. With the response time of the solenoid valve as analyzed above, the type of solenoid valve used is as required.
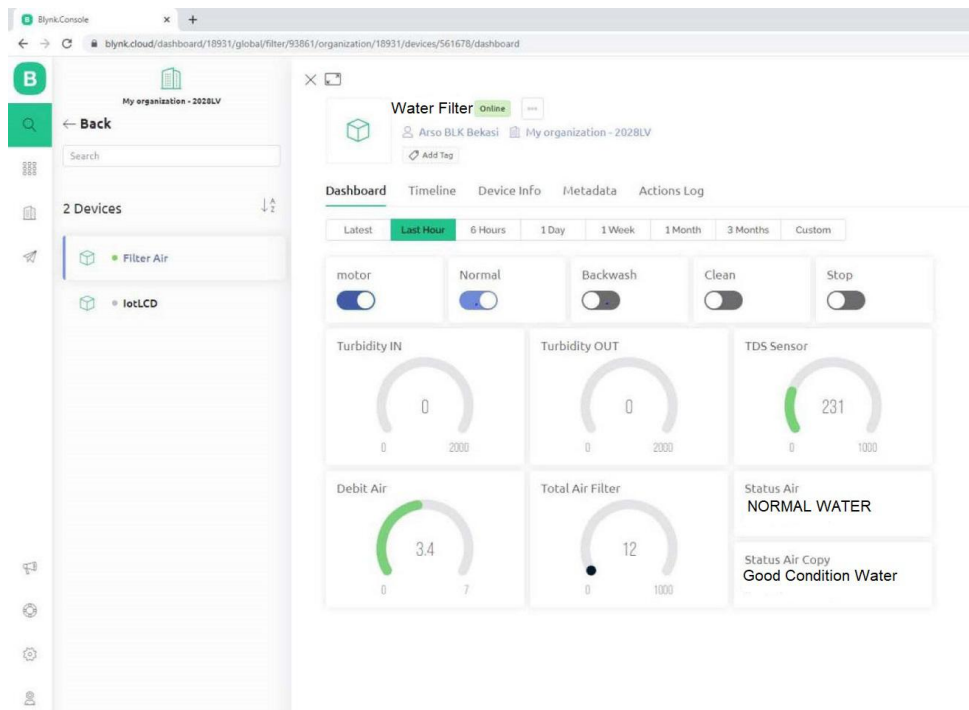
-Web Browser Display

Figure 19. Display on the Blynk IoT web dashboard

In Figure 19 is a monitor display of the water filter condition. By connecting to the internet and opening the web address that has been determined to monitor the water filter. In the display above, it can be seen that the tool is being set in the Normal operation process, there are 4 choices of operation processes above, namely there is normal where it is being selected, backswah, clean and stop. All sensor data is read on the IoT dashboard.

In clean water conditions the normal turbidity value is 0 - 50 NTU. Normal water readings on TDS are 0 - 500 ppm. The water flow reading on the device with a normal condition filter is between 3 liters / minute to 7 liters / minute. If the sensor reading on the system is not in accordance with normal conditions, the system will send a message according to the condition of the sensor reading, namely Normal Water / Abnormal Water and a good condition filter or a bad condition filter.

CONCLUSION

From the results of the design of this tool to the findings and discussion, the following conclusions can be drawn:

1. The average sensor output voltage reading is 2.92 V with a water turbidity value reading of 0 NTU for clear water conditions. And the average sensor output voltage reading is 0.91 V with a water turbidity value reading of 3000 NTU for turbid water. Where to get the result that the condition of the NTU value change in the tool tends to be more static. Referring to tables 3 and tables 4.

2. The difference in measurement values by comparing the measurement results of the TDS sensor with a reading accuracy of + 10% and the XMTDS01YM type TDS measuring instrument with a reading accuracy of + 10%. then from the measurement results get an average reading error of 3.74%. so in terms of reading the TDS sensor is quite accurate on the tool. Referring to tables 5 and tables 6.

3. In the process of testing the voltage and frequency values of the flow meter sensor, there are differences in measurement values by comparing the measurement results of the flow meter sensor with a reading accuracy of + 10%, then from the measurement results get an average sensor output voltage reading of 2.04V when the device is not operating and 4V when the device is operating. And also the measurement results get an average frequency value reading of 24.84 Hz when the device is not operating and 27.22 Hz when the device is operating, and get an average water discharge reading of 0.05 (m³/s) when the device is not operating and 5.52 (m³/s) when the device is operating. From these results it is concluded that the measurement of the flow meter sensor is quite accurate. Referring to tables 7 and tables 8.

4. The backwash operation system will run automatically if the TDS value is more than 500 ppm and the flow sensor is less than 3 liters / minute.

5. If the system has performed Backwash but the TDS value is above 500 ppm and the flow sensor is below 3 liters / minute then the system will send a message on the dashboard that the filter is not in good condition.

6. For the accuracy of the Turbidity sensor reading is 2 digits behind the comma (volt), the TDS sensor is 3 digits behind the comma (volt), and the Flow meter is 1 Hz.

7. The delay time from sending data until the data can be fully received by the web server is less than 1 second.

8. Sensor calibration refers to the reference in the sensor datasheet attached to the attachment sheet.

9. The operation of the tool has worked as desired both automatically and manually operated, and the filter condition monitoring data displayed on the LCD and web blynk is appropriate and reads in real time.

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