UNIVERSITI SAINS MALAYSIA

APEX

Development of IoT Water Quality Monitoring System

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Purpose

01

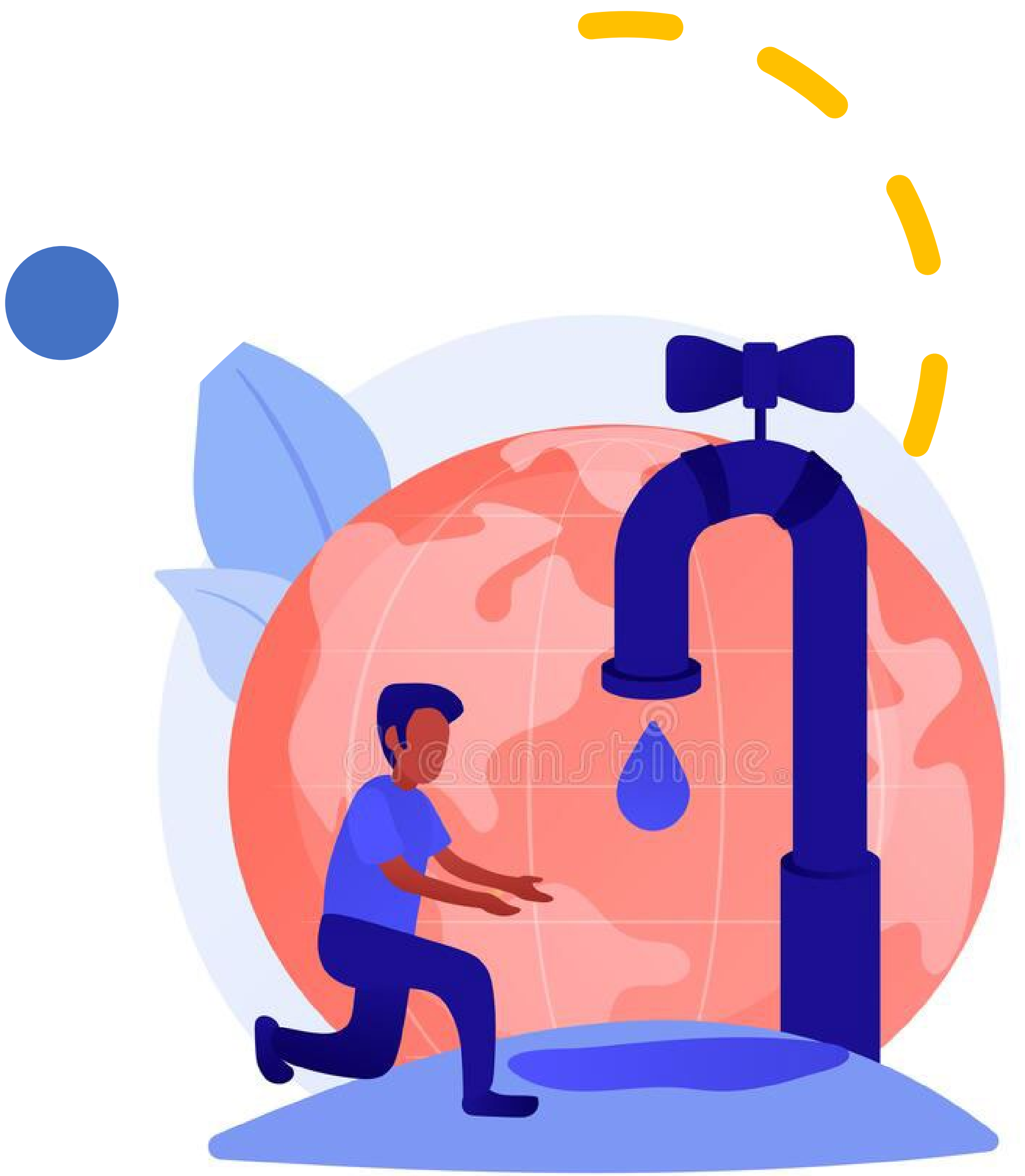
To develop a system which can perform real-time monitoring for the water reuse system.

02

To collect critical water reuse data to improve the household water use and water conservation purposes.

Background

- As water demand continues to increase across the globe, the availability of potable water continues to decrease, arsing from the climate changes and limited water resource.
- Lack of sustainable water management on the urban water system.
- Water reuse seems to be one of the viable solutions.
- Although many water reuse projects have been developed, many projects are rather lack of monitoring and maintenance.



Objectives

- To integrate the water quality sensors and performance of water quality measurement
- To send and store the water measurement data in cloud storage

Water Quality Standard in Malaysia

- From the Department of Environment of Malaysia, there are 5 classes for the water quality standard which are Class I, Class IIA/IIB, Class III, Class IV and Class V established. Each class is split based on the tolerance for each of the water parameter. Each class has different standard and usages.

ANNEX

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l	NATURAL LEVELS OR ABSENT	-	(0.06)	0.5	LEVELS ABOVE IV
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	μg/l		500	-	-	-
MBAS/BAS	μg/l		500	5000 (200)	-	-
O & G (Mineral)	μg/l		40; N	N	-	-
O & G (Emulsified Edible)	μg/l		7000; N	N	-	-
PCB	μg/l		0.1	6 (0.05)	-	-
Phenol	μg/l		10	-	-	-
Aldrin/Dieldrin	μg/l		0.02	0.2 (0.01)	-	-
BHC	μg/l		2	9 (0.1)	-	-
Chlordane	μg/l		0.08	2 (0.02)	-	-
t-DDT	μg/l		0.1	(1)	-	-
Endosulfan	μg/l		10	-	-	-
Heptachlor/Epoxide	μg/l		0.05	0.9 (0.06)	-	-
Lindane	μg/l		2	3 (0.4)	-	-
2,4-D	μg/l		70	450	-	-
2,4,5-T	μg/l		10	160	-	-
2,4,5-TP	μg/l		4	850	-	-
Paraquat	μg/l		10	1800	-	-

Notes :
* = At hardness 50 mg/l $CaCO_3$
\# = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA (cont.)

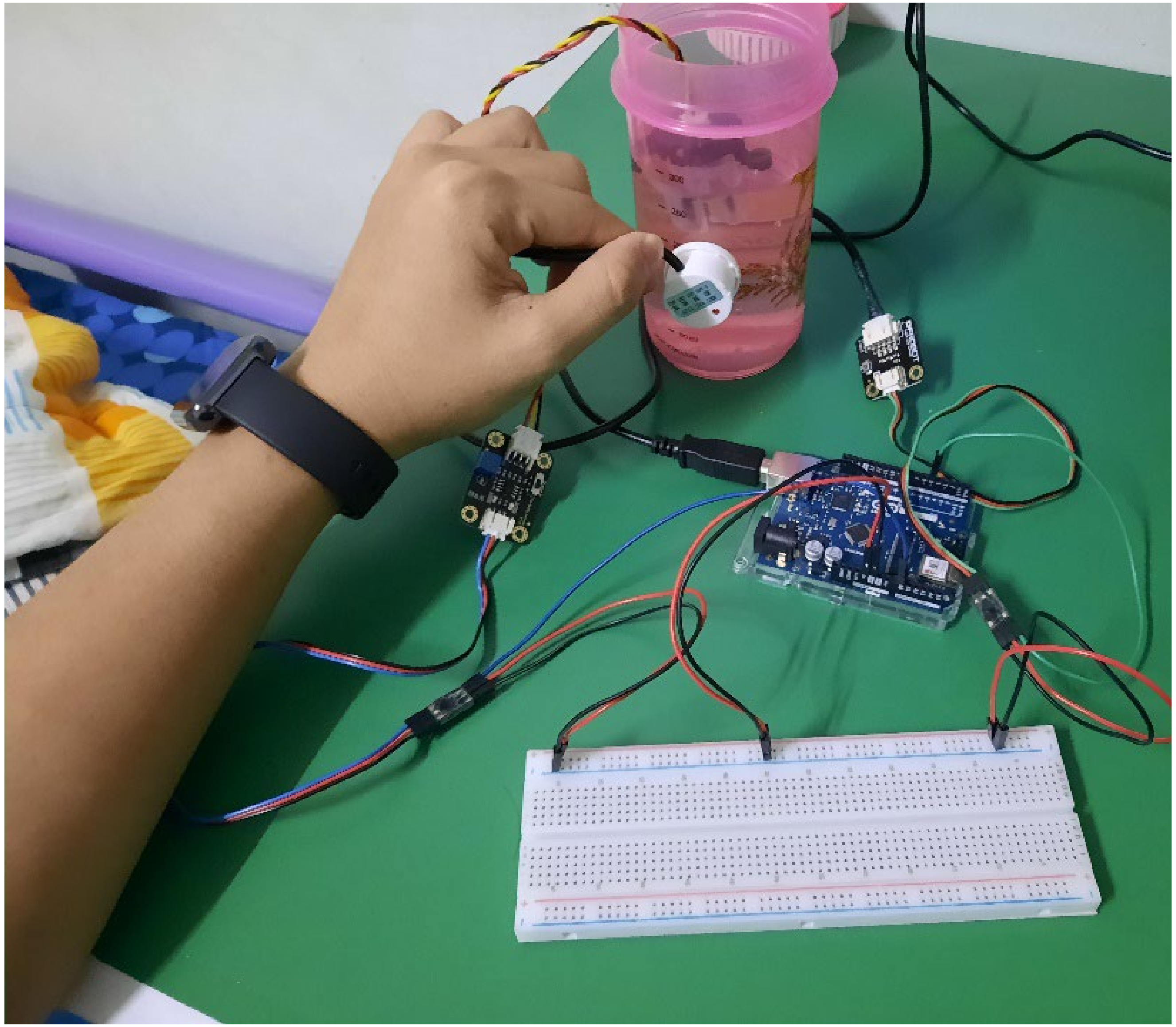
PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	μS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	ppt	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)[a]	5000 (20000)[a]	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

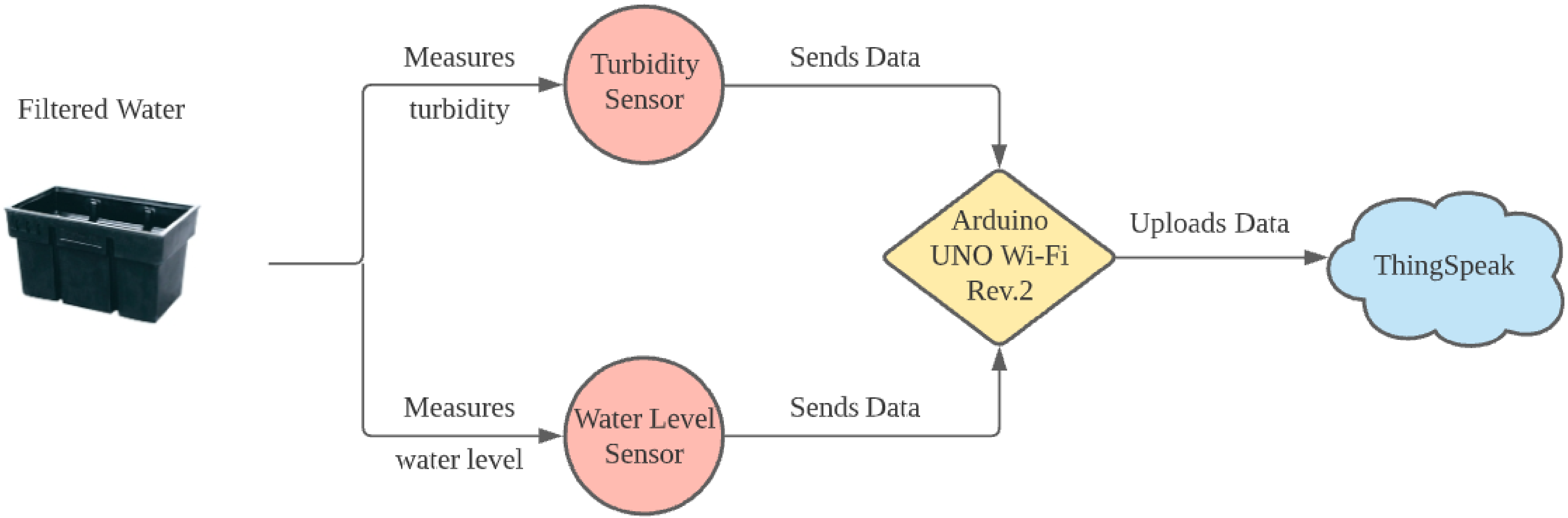
Notes :

N : No visible floatable materials or debris, no objectional odour or no objectional taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : Maximum not to be exceeded

Overview of the IoT Water Quality Monitoring System

- The IoT water quality monitoring system consists of water level sensor and turbidity sensor.
- All these sensors are connected and controlled by the microcontroller which is Arduino UNO Wi-Fi Rev.2 board.





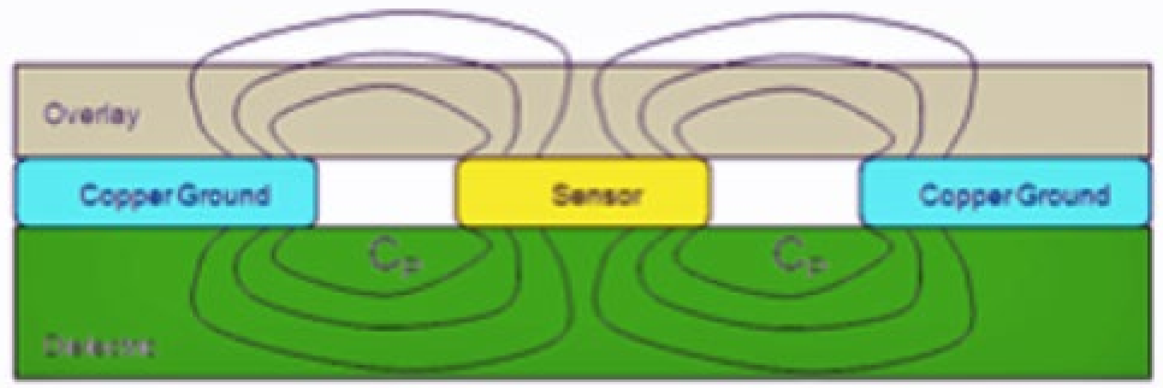
Working Mechanism of the IoT Water Monitoring System

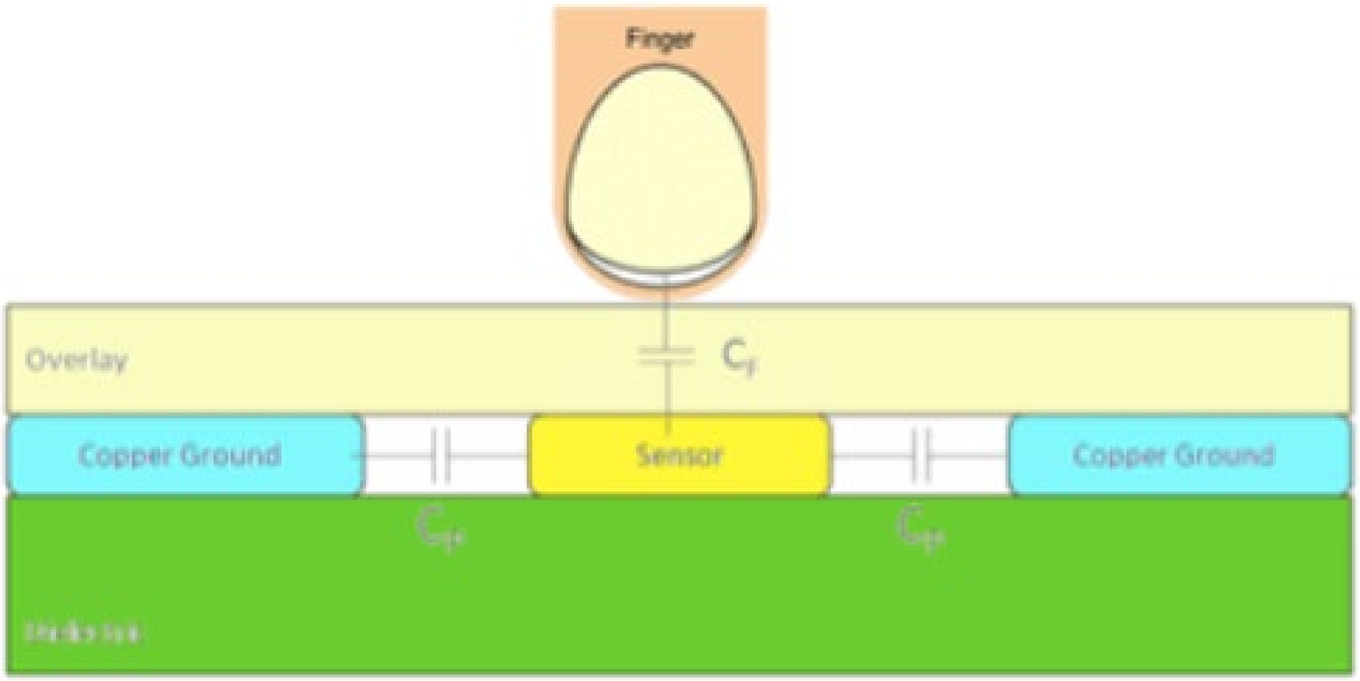
- The sensors will continuously measure the quality of the filtered water (for now, turbidity and water level) and the data will be read and uploaded by Arduino to a cloud server which is ThingSpeak.
- Since it is stored in cloud server, the data can be easily accessed anytime, anywhere.

Type of Sensors Used

1. DFRobot Non-contact Liquid Level Sensor

- Uses water sensing capacitor to detect the liquid level.
- Without water, there will be a presence of distributed capacitance. This results certain amounts of static capacitance to ground on the sensor.
- When there is liquid near the sensor, the parasitic capacitance of the liquid will be coupled to the static capacitance so that the final capacitance value of the sensor becomes larger and the changed capacitance signal is then input to the control IC for electrical signal conversion.

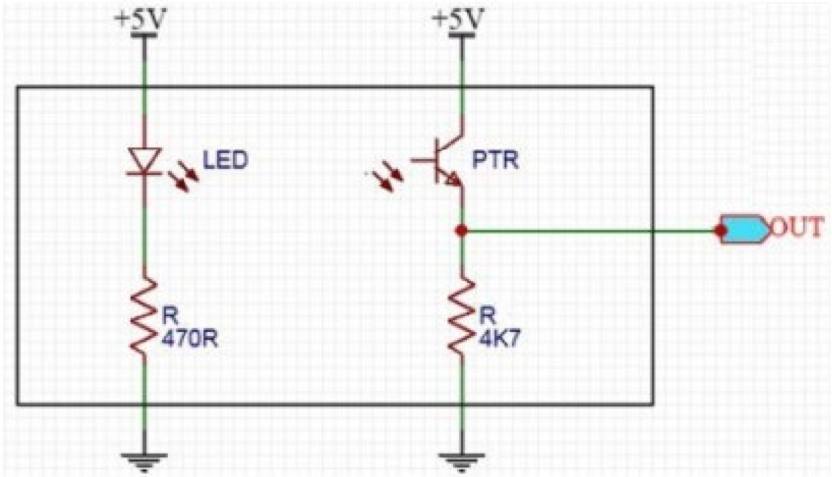

Overlay
Copper Ground
Sensor
Copper Ground
C_p
C_p

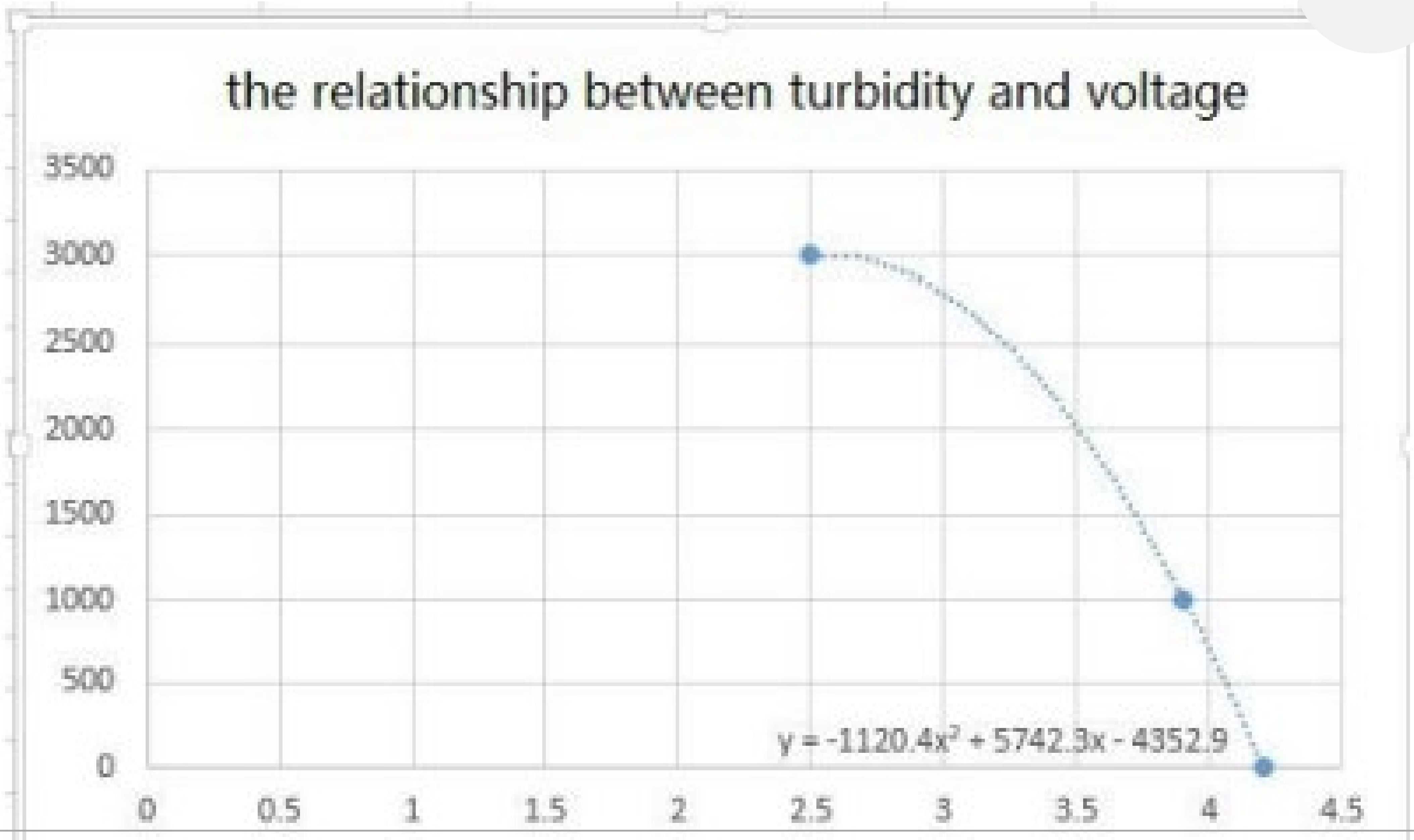

Finger
Overlay
C_f
Copper Ground
Sensor
Copper Ground
C_p
C_p

Type of Sensors Used

2. DFRobot Turbidity Sensor

- Uses light to detect suspended particles in water
- Beams of light will be produced from the photoemitter and it needs to pass through the water before it reaches the phototransistor.
- The cloudiness of the water will affect the amount of light received at the phototransistor. It will then affect the voltage that is allowed to pass through. Voltage value is converted to NTU in the coding.
- The higher the voltage produced, the lower the NTU, the clearer the water.





the relationship between turbidity and voltage
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
y = -1120.4x² + 5742.3x - 4352.9

Demonstration on IoT Water Quality Monitoring System

How to upload data to ThingSpeak

Sign In - ThingSpeak IoT

thingspeak.com/login?skipSSOCheck=true

Apps | Pauls Online Math... | Materials and Proce... | Home - Engineerin... | StuDocu - Free sum... | Kick Start - Google'... | Electronic library. D... | A High Precision Po... | Other bookmarks | Reading list

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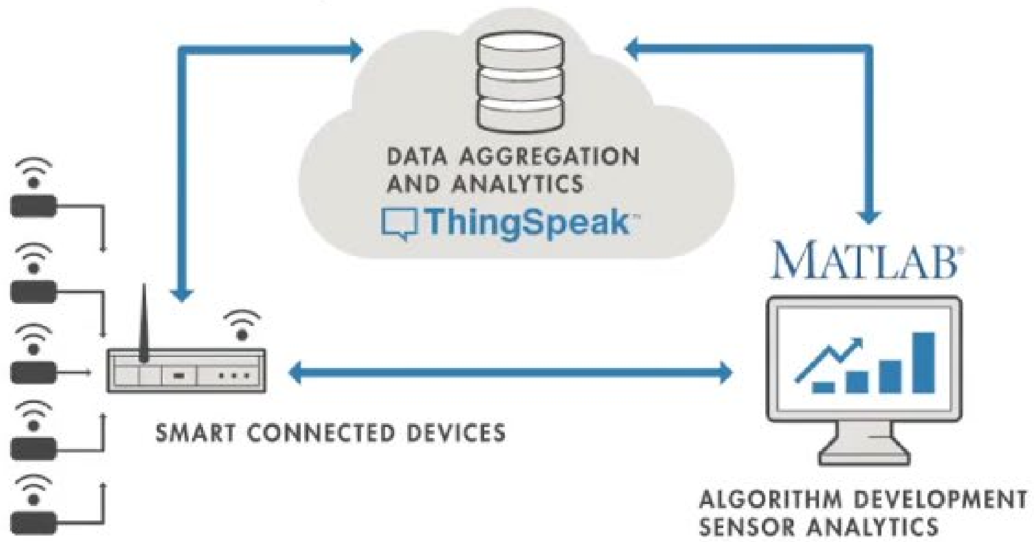

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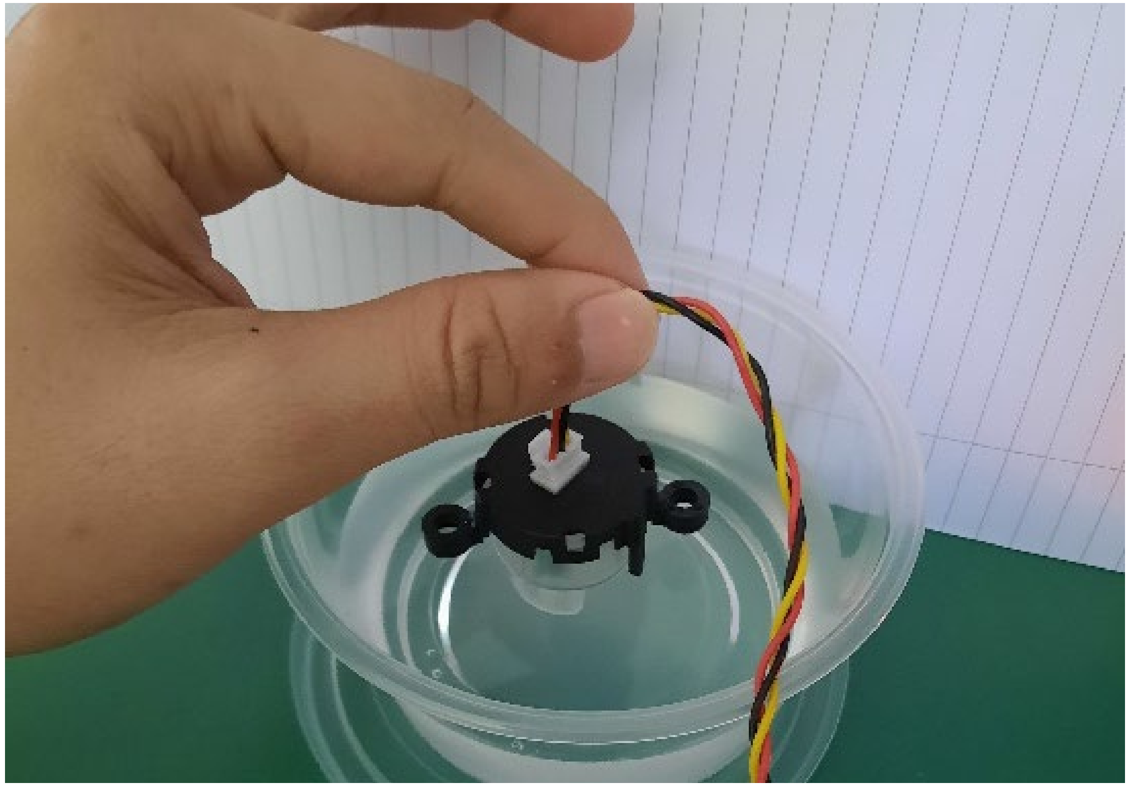
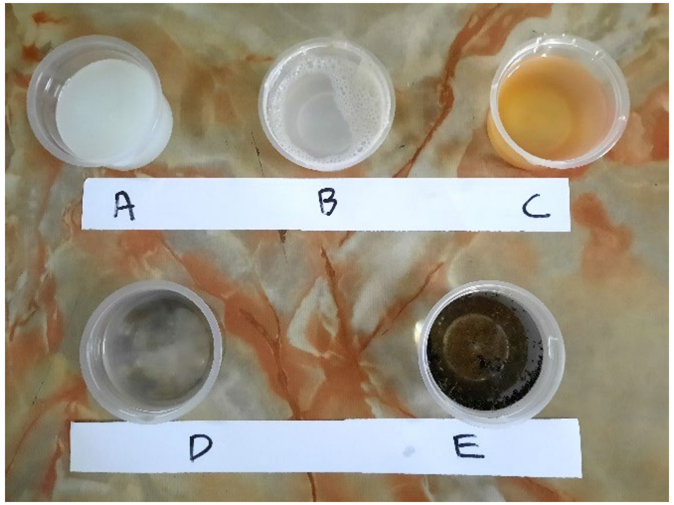
Turbidity Measurement on Known Turbidity Samples



SOLUTION	TURBIDITY MEASURED (NTU) Test 1	Test 2	Test 3	AVERAGE VALUE (NTU)
Clear Drinking Water	-36.80	0	0	-12.27
Calcium Carbonate Solution (675 NTU)	2534.27	2534.27	2519.65	2529.40
Calcium Carbonate Solution (413 NTU)	752.97	784.62	721.09	752.89

Turbidity Measurement on Domestic Wastewater Samples



Sample	Description
A	Toothpaste, Face Cleanser, Mouthwash
B	Body Shampoo, Hair Shampoo
C	Tomato Sauce, Dish Detergent
D	Washing Detergent, Dirt from Clothes
E	Rainwater, Soil

Sample	Turbidity Measured (NTU)
A	3000
B	1127.32
C	1458.26
D	546.63
E	1467.16

Advantages of IoT System

Data can be accessed anytime, anywhere without the need to be presence on the site.

Different IoT systems can be connected and form a large comprehensive system that can detect and control the water quality of the water reuse system

Plan for connected projects

This project is closely related to another project entitled “Image Segmentation and Fusion” which is handled by Teoh Mynn Wei from Universiti Sains Malaysia. In this project, image segmentation and fusion technique is used to count the colony-forming unit (CFU) of *E. coli* on the test piece that is used on filtered reuse water. CFU is extremely important in determining whether the water is up to standard for different use cases. After that, the analysis is uploaded to the cloud server, allowing authorities to access the data anytime and anywhere.

Acknowledgment

This work is the output of the ASEAN IVO (http://www.nict.go.jp/en/asean_ivo/index.html) project, IoT for water reuse in developing cities, and financially supported by NICT (http://www.nict.go.jp/en/index.html).

Thank you