DEVELOPMENT OF A LOW-COST SOLAR POWERED & REAL-TIME WATER QUALITY MONITORING SYSTEM FOR MALAYSIA SEAWATER AQUACULTURE: APPLICATION & CHALLENGES

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Video Presentation URL: https://youtu.be/RFbM3QwcXac

ASEAN IVO FORUM 2020

EUTROPHICATION

- Marine aquaculture faces the similar challenge as the freshwater especially the threat of the harmful algae bloom (HAB) i.e. Eutrophication. Eutrophication is a condition where water columns are rich in nutrients (particularly phosphorus and nitrogen) consequences by the regular fish feeding as well as the discharge of fertilizers, or sewage into an aquatic system [1].
- This stimulates the HAB. Toxic HAB could cause illness an death to aqua life including fishes whilst the non-toxic ones are microalgae that can cause damage to fisheries resources [2].
- Eutrophication inflicted turbidity (amount of suspended sediment in water i.e. water clarity) that affect aquatic life [3]. The growth of algae increases water turbidity. Algae blocks light passing through hence narrowing the light spectrum below the water surface. These altered light conditions have shown to affect the reproductive behavior of fishes [3,4] indirectly affecting fisheries production.

[1] Chislock, M. F., Doster, E., Zitomer, R. A. & Wilson, A. E. (2013) Eutrophication: Causes, Consequences, and Controls in Aquati c Ecosystems. Nature Education Knowledge 4(4):10
[2] Anderson, D.M. (2009) Approaches to monitoring, control and management of harmful algal blooms (HABs). Ocean Coast Manag52(7): 342.
[3] Jarvenpaa, M. & Lindstorm, K. (2004) Water turbidity by algal blooms causes mating system breakdown in a shallow-water fish, the sand goby Pomatoschistus minutus. Proceeding Bological Science 271 (1555):2361.
[4] Wells, M.K., Trainer, V.L., Smayda, T.J., Karlson, B.S.O., Tricke, C.G., Kudela, R.M., Ishikawa, A., Bernard, S., Wulff, A., Anderson, D.M. & Cochlan, W.P. (2015) Harmful algal blooms and climate change: Learning from the past and present to forecast the future. Harmful Algae 49: 68–93.

PROFILING ENVIRONMENT FACTORS

- Ecology researchers have highlighted that environmental factors facilitated algae growth [5]. Amongst them are water temperature, ambient temperature, turbidity, solar radiation, total suspended solids (TSS), ph, salinity, and chlorophyll-a.
- The readings of these parameters have been profiled by manual sampling and human observation on bloom occurrence. This requires researcher presence in situ to take the readings at certain interval e.g weekly [6]. This forbid the detection and tracking of algae blooms that is yet needed [2].
- Conventional monitoring processes involve the manual collection of samples from various points in the distribution network, followed by laboratory testing and analysis. This process is laborious, time-consuming and lacks real-time results to promote proactive response to water contamination. This whole process can be facilitated by the use of sensors technology and data analytics, instead. **Thus, in our work, sensors are used to overcome the manual profiling whereby sensors such as temperature, pH, and turbidity meter could be installed around the fish farm and the readings will be profiled continuously and store in a server.**

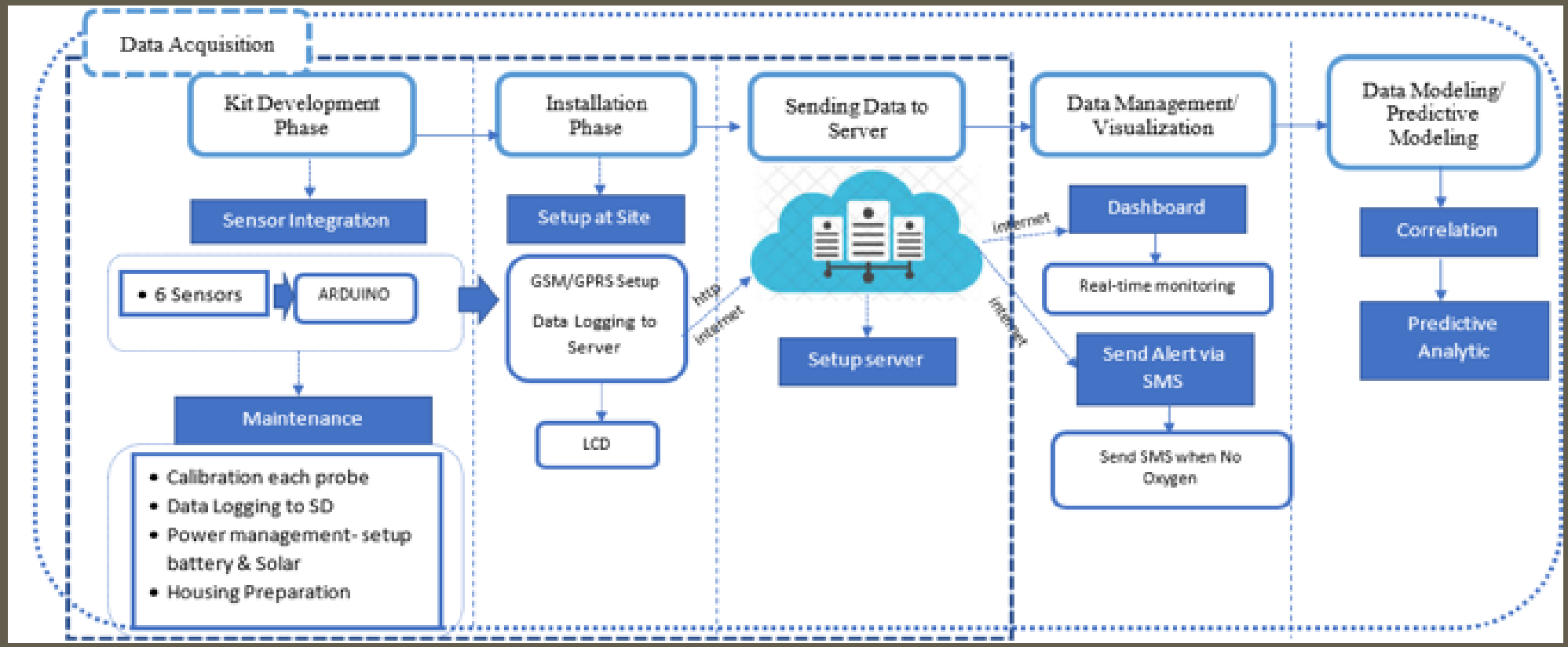
[2] Anderson, D.M. (2009) Approaches to monitoring, control and management of harmful algal blooms (HABs). Ocean Coast Manag52(7): 342.
[5] Huang, J.D., Zheng, H.R. (J.) & Wang, H.Y. (2017) Current Trend of Metagenomic Data Analytics for Cyanobacteria Blooms. Journal of Geoscience and Environment Protection 5:198-213.
[6] Whitehead, P.G., Howard, A. & Arulmani, C. (1997) Modelling algal growth and transport in rivers: a comparison of time series analysis, dynamic mass balance and neural network techniques. Hydrobiologia 349: 39

PREDICTIVE ANALYTICS

- Despite the limitation on manual profiling, the task of modeling algal bloom has long been initiated. The earliest work was by [6] that modeled three years of weekly data for river flow, temperature and chlorophyll-a at six sites along River Thames using time series analysis, dynamic mass balance and growth equations and neural network.
- In 2009, Stumpf et al. [7], develop a forecast system of HAB in the Gulf of Mexico. The system incorporates satellite image, wind predictions and rule-based model to forecast based on temperature, salinity etc.
- There are other methods used in predicting blooms incorporating machine learning techniques. These works focus on establishing relationships between these environmental parameters and the blooming occurrence. Among parameters that were often used are water temperature, ambient temperature, turbidity, and salinity.
- Based on the literature, predictions on algal blooms are reliable and can be used as a monitoring (involving detection and tracking) mechanism on algal growth. **This, will provide us information on the algal growth window which is needed to fulfill our aim at monitoring the seawater quality and providing the necessary responses.**

[6] Whitehead, P.G., Howard, A. & Arulmani, C. (1997) Modelling algal growth andtransport in rivers: a comparison of time series analysis, dynamic mass balance and neural network techniques. Hydrobiologia 349: 39
[7] Stump, R.P., Tomlinsona, M.C., Calkins, J.A., Kirkpatrick, B., Fisher, K., Nierenberg, K., Currier, R. & Wynne, T. (2009) Skill assessment for an operational algal bloom forecast system. Journal of Marine System 76(1-2): 151–161.

OUR FRAMEWORK



Framework of complete low-cost real-time water quality monitoring system [8]

[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

SOLAR POWERED LOW-COST SENSORS ASSEMBLE

Kit Development Phase

Sensor Integration

- pH
- EC
- DO
- Turbidity
- Temperature
- TDS

→ ARDUINO

Maintenance

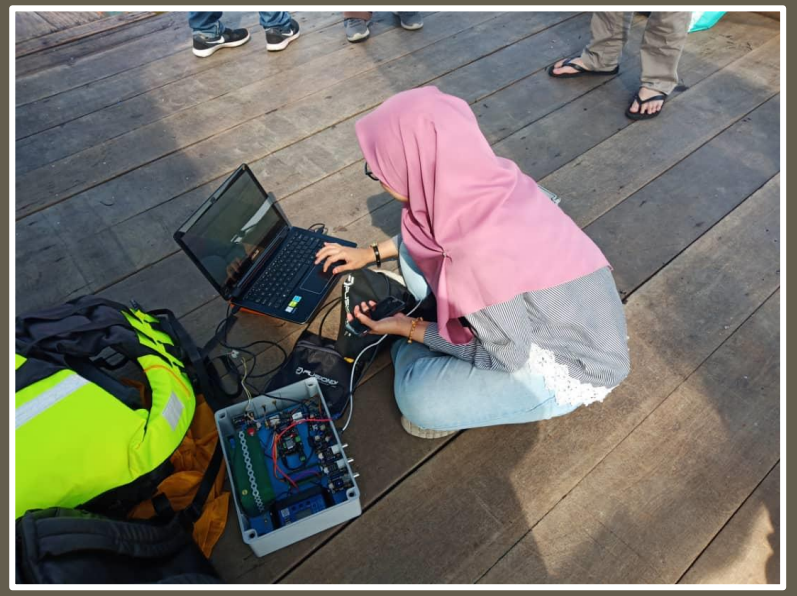
- Calibration each probe
- Data Logging to SD
- Power management- setup battery & Solar
- Housing Preparation

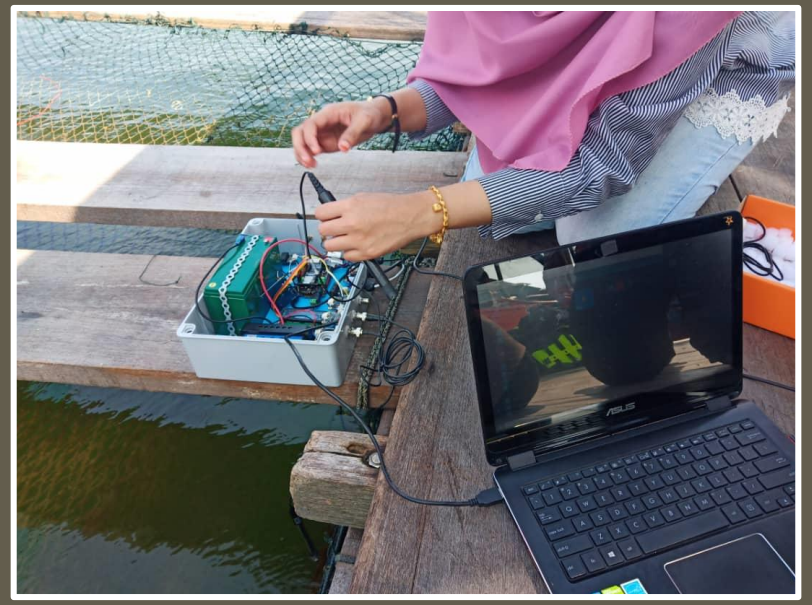
Sensor/ Equipment	Cost (RM)	Sensor/ Equipment	Cost (RM)
Arduino	80	Temperature	11
Expansion Shield	36	Turbidity	40
pH	119	Solar Panel & Controller	133
DO	687	Battery	44
TDS	40	Jumper Wire	3
EC	284	Waterproof Box	35
		Total Cost	RM1,512

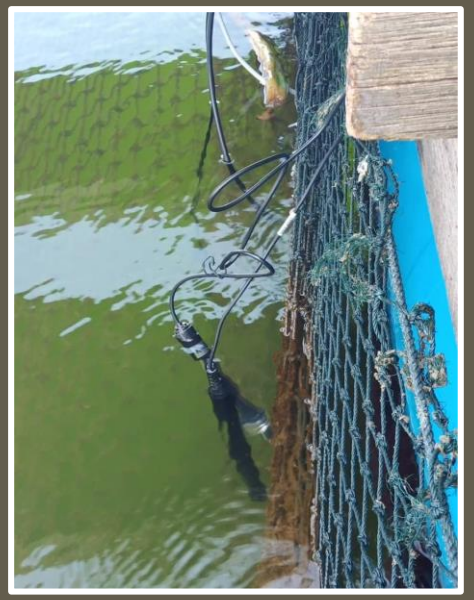
[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

INSTALLATION

1st visit – Testing the first set (calibration and testing server connection)







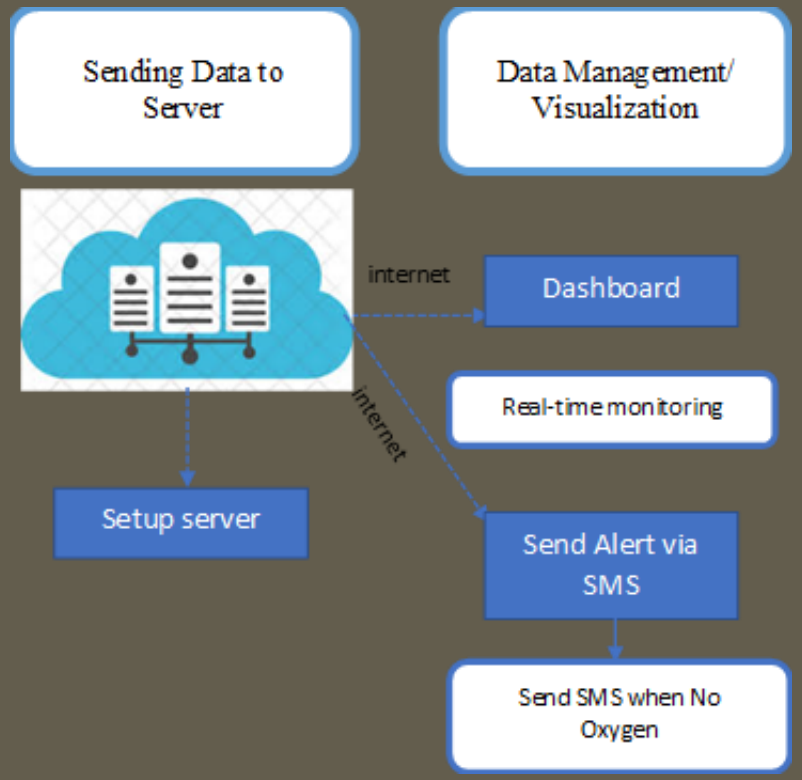
[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

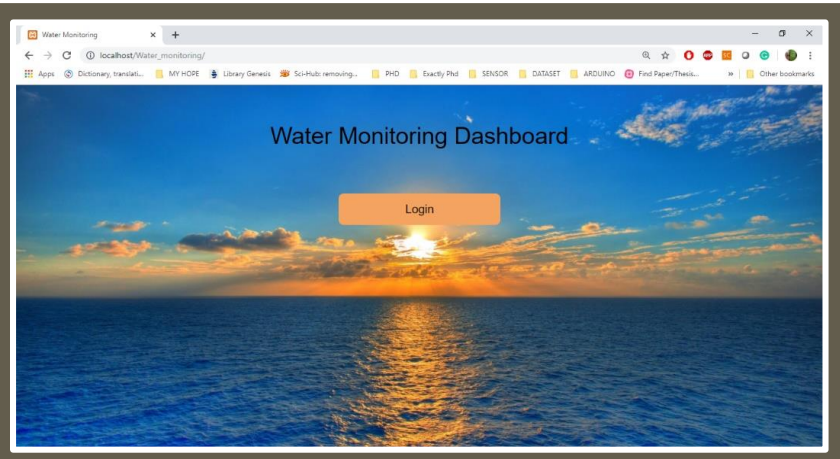
INSTALLATION

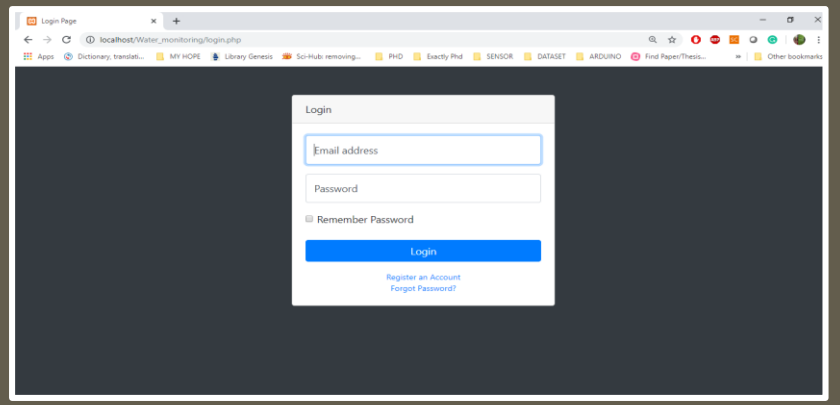
2nd visit – 5 sets installation

[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

DATA MANAGEMENT & VISUALIZATION



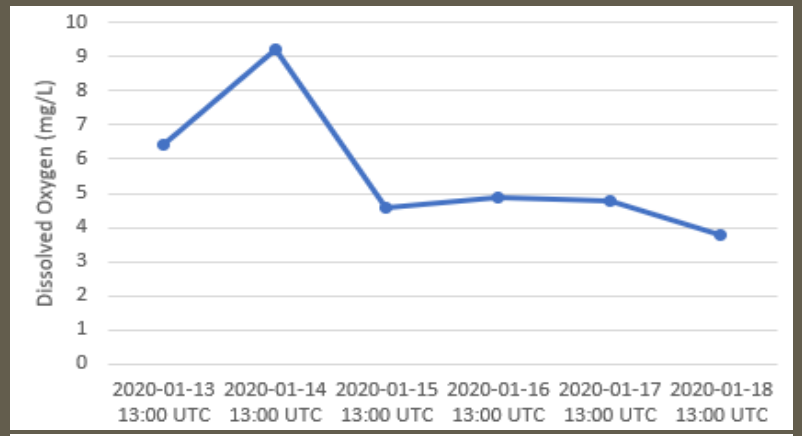


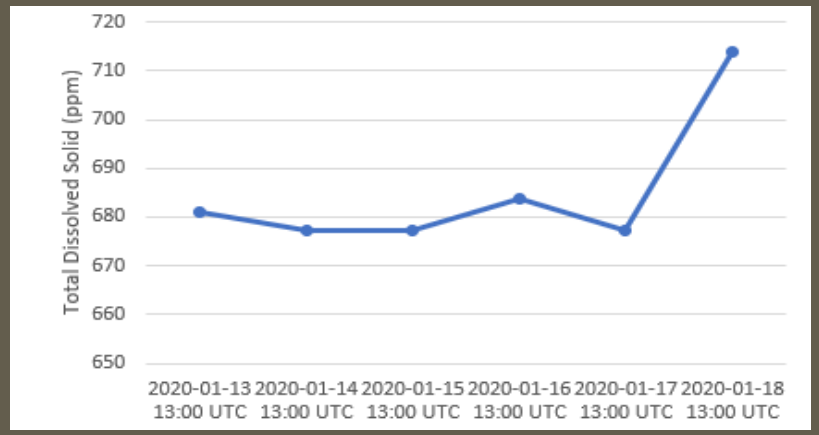


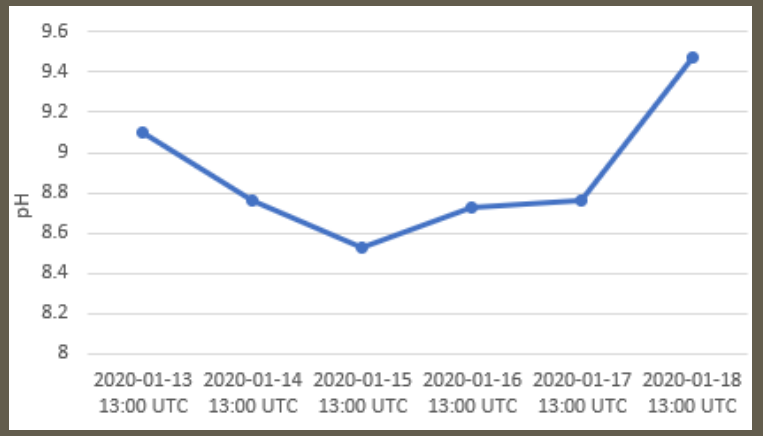

```
If (DO_val>35) // to put certain threshold
   {
      Serial.println("Need extra monitoring");
      Serial.println("Calling to inform");
      Sim900_test.callUp(PHONE_NUMBER);    /* Call */
     /* Check if new message available */
          while( (messageIndex < 1) && !strstr(
message,"Alert: Low oxygen detected!") )
   }
```

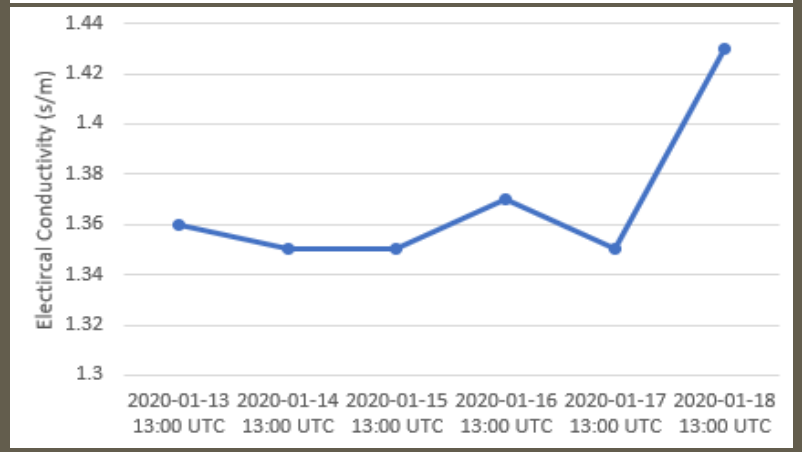
[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

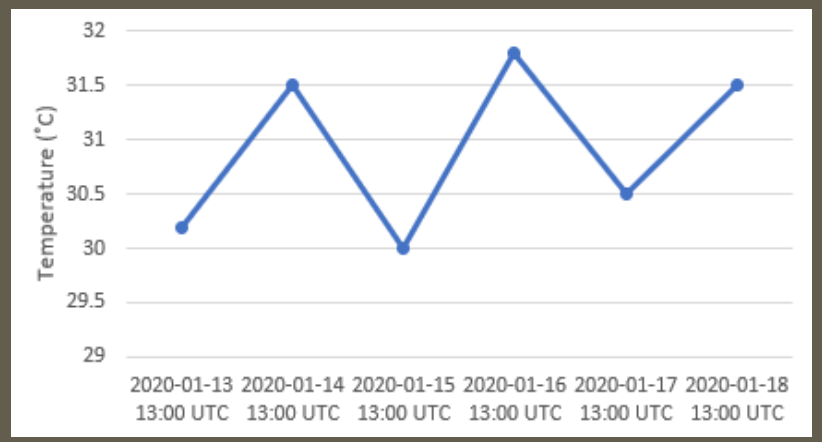
DATA MANAGEMENT & VISUALIZATION

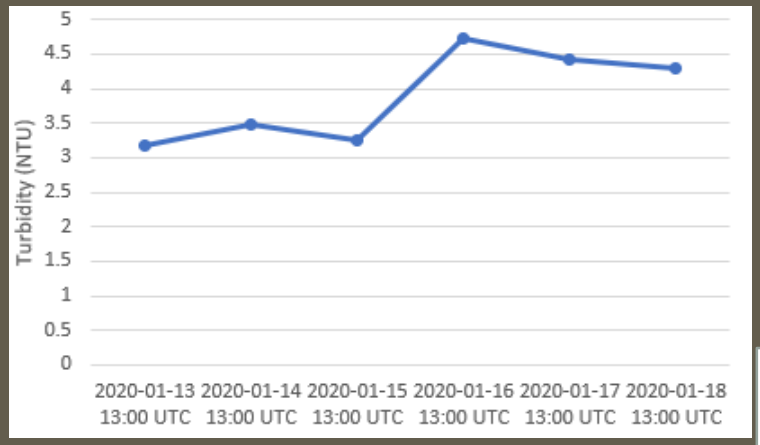












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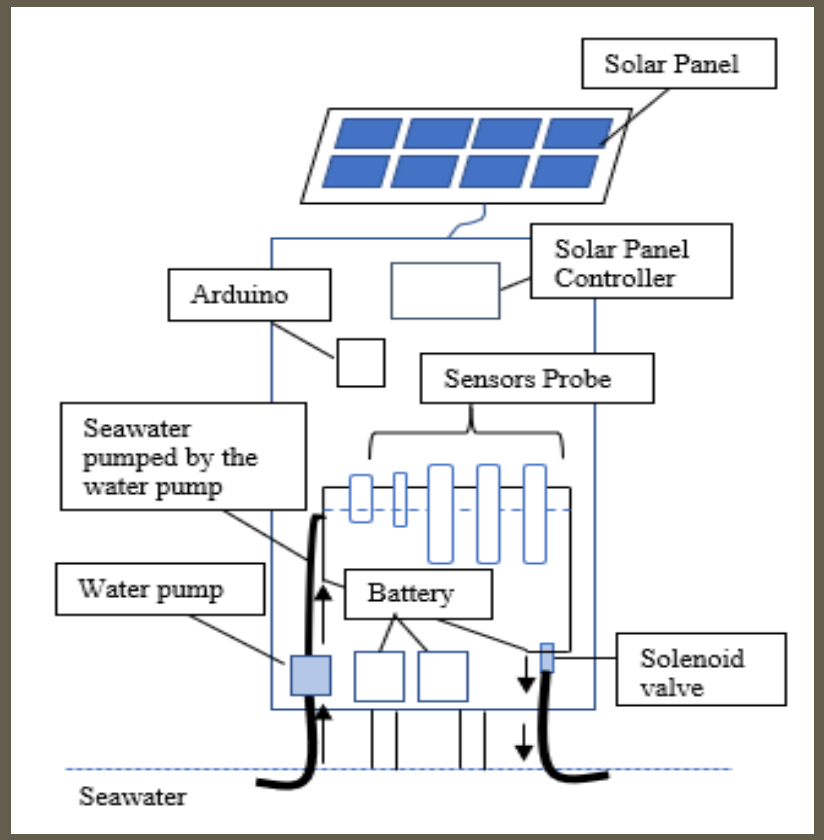
CHALLENGES

3rd visit – Checking sensors due to no readings captured in server

[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

IN PROGRESS



- Pump-based sensors assembled
- Predictive algorithm for multiple stressor (combined parameters)
- In-house water quality monitoring system

[8] N.A.P. Rostam, N.H.A.H Malim, & R. Abdullah. 2020. Development of a Low-Cost Solar Powered & Real-Time Water Quality Monitoring System for Malaysia Seawater Aquaculture: Application & Challenges. In Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing (ICCBDC '20). Association for Computing Machinery, New York, NY, USA, 86–91

ON-GOING PROJECT DETAILS

Program Title:

Solar Powered Membrane Distillation for Desalinating Algae Blooming Seawater: Separation, Fouling, and Energy Efficiency Study

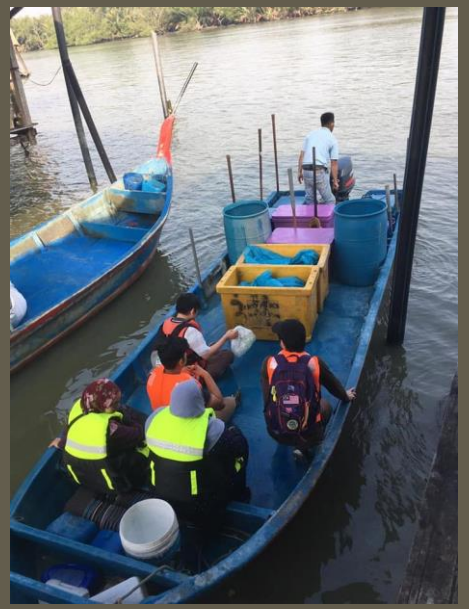
Project title:

Sensor-based profiling and predictive analytics of solar flux and water quality on the seawater aquaculture farm

Fund:

Transdisciplinary Research Grant (TRGS/1/2018/USM/01/5/4-203.PKOMP.67612) by Ministry of Higher Education Malaysia

MORE PICTURES



THANK YOU

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