Journal of Aquaculture and Fish Health Vol. 11(2) - June 2022
DOI : 10.20473/jafh.v11i2.31487

Automated Redox Monitoring System (ARMS): An Instrument for Measuring Dissolved Oxygen Levels Using a Potential Redox Sensor (ORP) in a Prototype of Shrimp Farming Pond with an Internet-Based Monitoring System

Ridwan Siskandar[1*], Wiyoto[2], Andri Hendriana[2], Julie Ekasari[3], Billi Rifa Kusumah[4], Glenaldin Halim[1] and Indi Jaka Nugraha[1]

[1]Study Program of Computer Engineering, College of Vocational Studies, IPB University, Bogor 16128, West Java, Indonesia

[2]Study Program of Production Technology and Management of Aquaculture, College of Vocational Studies, IPB University, Bogor 16128, West Java, Indonesia

[3]Department of Aquaculture, Faculty of Fisheries and Marine Science, IPB University, Bogor 16680, West Java, Indonesia

[4]Study Program of Fishing Technology, Faculty of Marine and Fisheries Technology, Nahdlatul Ulama University of Cirebon, Cirebon 45111, West Java, Indonesia

*Correspondence :
ridwansiskandar@apps.ipb.ac.id

Received : 2021-11-20
Accepted : 2022-04-12

Keywords :
ARMS, Potential redox sensor, Shrimp farming, Smartphone

Abstract

A data acquisition system for measuring and storing dissolved oxygen levels has been implemented to monitor water quality levels in shrimp culture media using an internet-based potential redox sensor (ORP). The purpose of this study is to apply ARMS, an instrument for monitoring internet-based potential redox data (dissolved oxygen levels) in shrimp culture media in real-time to determine the condition of water quality. This system is designed using an ORP sensor that uses WIFI communication. In principle, when the ORP sensor is placed in the water in the shrimp culture media, the potential redox data will be detected by the sensor connected to the ESP8266 which processes and transmits data which is then displayed and analyzed on the smartphone interface. In this study, 9 units of shrimp culture media prototype ponds were used for observational tests. The object of observation in the pond is water quality data in the form of sediment potential redox values. At this stage of research, two processes of observation of data collection were conducted. The first process is to monitor water quality conditions on the user's smartphone display, in the form of the potential redox value of each pool measured by the ARMS instrument for 12 weeks. The second process is to compare the potential redox observation data measured by the ARMS instrument and the ORP Meter in each pool. Observation of comparative data took place during the 6th week. The sediment potential redox values for treatments 1, 2, and 3 were 69 mV, 151 mV, and 210 mV respectively. The average redox potentials in the water are in the range of 90.56 mV to -263 mV for treatment 1; 90.75 mV to -62,934 mV for treatment 2; 90.65 mV to 60.73 mV for treatment 3. This range is the measurement range from week 0 (shrimp seed stocking) to week 4. The results of the

DOI : 10.20473/jafh.v11i2.31487

comparison of the two tools show that the accuracy of the ARMS tool is more than 95%.

INTRODUCTION

Advances in the field of information technology and embedded systems in the digitalization era are increasingly leading to the study of control and monitoring systems, the internet of things, and control systems. Research in this field, especially the topic of measuring water quality in microcontroller-based aquaculture is very interesting to review, as has been done by previous researchers (Suwoyo *et al.*, 2013; Mardhiya *et al.*, 2018; Said, 2014; Salfia *et al.*, 2018; Al Barqi *et al*., 2019; Siskandar and Kusumah, 2019; Kusumah *et al*, 2020; Alfiansyah, 2020; Eridani *et al*., 2020; Pauzi *et al.*, 2020; Wicaksono *et al.*, 2021; Suciyati *et al.*, 2021; Kusumah *et al.*, 2022).

Water as a living medium for shrimp certainly contains dissolved oxygen which is used for the breathing process and as a source of several minerals for shrimp. Dissolved oxygen demand is the main factor influencing the processes and conditions at the boundary between water and culture media sediments. The need for oxygen consumption in the sediment is an indicator of the intensity of the mineralization process and the metabolism of the shrimp community (Mardhiya *et al.*, 2018; Pauzi *et al.*, 2020; Kusumah *et al*., 2021).

Salfia *et al.* (2018) in his research revealed that the use of total oxygen in shrimp ponds is dominated by sediment, pond water, and shrimp. The level of oxygen consumption of sediment is an indication of the activity of microorganisms in the substrate and is a picture of oxygen demand which can be known through the consumption or process of using dissolved oxygen in ponds or water bodies. Under certain conditions, oxygen consumption by the sediment causes the redox potential at the bottom to below.

One of the water qualities that need to be considered is the level of oxygen and potential redox dissolved in the water (Salfia *et al.*, 2018). Dissolved oxygen level (DO) is the amount of oxygen available in a body of water. Lack of oxygen levels can cause stress and easily contracted diseases and stunted growth. In addition, the level of shrimp consumption will decrease if the oxygen needs in the water are not met and resulting in a decrease in shrimp health conditions and even causing death (Mardhiya *et al.*, 2018).

The accumulation of organic matter in an amount that is not under the carrying capacity of the land will have a negative impact because it can increase the rate of oxygen depletion in the water, can increase the oxygen demand in the bottom sediment, and can reduce the redox potential to a reduction level (Pauzi *et al.*, 2020). If this continues, it will worsen the conditions of the aquaculture environment, especially the subgrade water layer, and will produce reduced compounds such as NH_3, CH_4, and H_2S which are toxic and create unsuitable habitat for shrimp (Mardhiya *et al.*, 2018; Al Barqi *et al*., 2019; Wicaksono *et al.*, 2021).

Based on the above background, the researcher took a study entitled "Automated Redox Monitoring System (ARMS): An Instrument for Measuring Dissolved Oxygen Levels Using a Redox Sensor (ORP) on a Prototype of Shrimp Cultivation Pond with an Internet-Based Monitoring System". The purpose of this study is to apply ARMS, which is an instrument for monitoring potential redox data (dissolved oxygen levels) in shrimp culture media in real-time based on the internet to determine the condition of water quality. In the future, this device is expected to have a good impact on shrimp farmers in the era of increasingly developing technology. The monitoring system developed also provides a good

DOI : 10.20473/jafh.v11i2.31487

solution during the COVID-19 pandemic because shrimp cultivators do not need to come directly to the culture media to check the water quality of the shrimp culture media.

METHODOLOGY

Place and Time

This experimental research process was carried out at the Hardware Laboratory and Fish Tank Laboratory, College of Vocational Studies, IPB University starting from April to August 2021.

Research Materials

The materials and tools used in this research include the ARMS instrument which consists of the ORP sensor as a data measuring component; NodeMCu ESP8266 as processor or brain to command, control, and process data; website as a data display or delivery system to manage commands that can be viewed using a Smartphone device or computer supported by the internet network. Then the ORP Meter Instrument as an ARMS commercial comparison sensor. The prototype pond of shrimp culture media (dimensions of height and radii of 57 cm and 23.5 cm) consisted of 9 units which were stocked with 25 shrimp in 3 ponds, 50 fish in 3 ponds, and 75 fish in 3 ponds. The software used for data processing analysis is excel software.

Research Design

The number provided for the observation test is 9 units. In the 1st to 1st treatment pond. 3, 75 shrimp were stocked, in the 4th to 4th treatment ponds. 6, 50 shrimp were stocked, while in the 7th to 7th treatment ponds. 9 stocked with 25 shrimp. The data that becomes the object of observation in the pond is water quality data in the form of sediment potential redox values.

Work Procedure

Instrument Working Algorithm

In this study, a monitoring device system is installed in shrimp culture media, where data acquisition for potential redox measurements is obtained from readings using a potential dissolved redox (ORP) sensor. In principle, this instrument system consists of three important parts, namely: input (dissolved oxygen sensor), input data processor/processor (ESP8266 microcontroller), and output (smartphone) which can be opened via PC, laptop, or smartphone. The dissolved oxygen sensor readings will be processed by the ESP8266. The ESP8266 then orders through the fiber base to display the sensor readings that have been processed by the ESP8266 to be displayed through the smartphone interface. The sketch of the monitoring system on the prototype of shrimp culture media is shown in Figure 1.

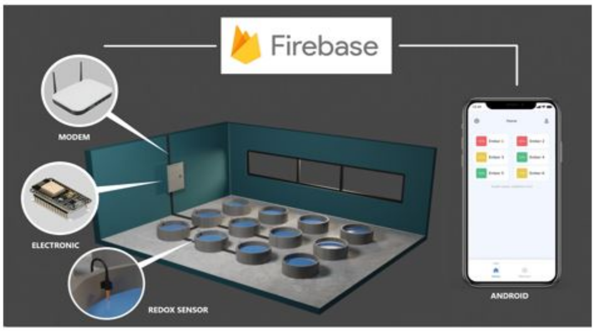

Figure 1. The working principle of the monitoring system for measuring oxygen levels with a redox sensor (ORP) on shrimp culture media.

The process of implementing the prototype of a shrimp culture pond is adjusted to the design in the sketch as shown in Figure 1. Measurement of

DOI : 10.20473/jafh.v11i2.31487

oxygen levels using a redox sensor on the prototype of a shrimp pond is shown in Figure 2. The description of the process of measuring oxygen levels in shrimp culture media is shown in Figure 3.

Figure 2. Monitoring system on internet-based shrimp culture media prototype.

Figure 3. Display of the process of measuring oxygen levels in shrimp culture media.

Internet-Based Instrument Monitoring Work System

To access the ARMS website, several steps can be followed, firstly accessing the website address through a browser application found on a smartphone or laptop. This website is recommended to be accessed via a smartphone because it is specifically designed to be accessed via a smartphone. Second, when the page is successfully accessed, the user will be immediately directed to the “Home” page. An illustration of the working principle of the internet-based monitoring system page can be seen in Figure 4.

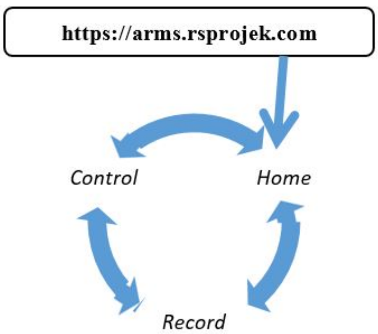

Figure 4. Illustration of the internet-based monitoring system page display.

All users/users from anywhere can monitor the measurement data, namely redox or oxygen levels through a website tool with the domain name https://arms.rsprojek.com. The menu page available to users consists of three parts, namely, Home to display the oxidation value in real-time which has been processed by the hardware. Record to display a collection of monitoring results from oxidation values in tabular form, and Control to set the time interval (in milliseconds) and to set the hardware to update and also save monitoring data to the database.

Data Analysis

Two processes of observation of data collection were carried out. The first process is to monitor water quality conditions on the user's smartphone display, in the form of the potential redox value of each pool measured by the ARMS instrument, with a measurement duration of 12 weeks. The second process is to compare the potential redox observation data measured by the ARMS instrument and the ORP Meter in each pool. Comparative observations of this data were taken during the 6th week.

The data obtained from the results of these observations will be processed and displayed in the form of tables, and graphs that are easy to understand. The display of the website page from the ARMS display will be shown in the observations.

RESULTS AND DISCUSSION

ORP Sensor Test

The ORP sensor is a potential redox detection sensor in a container filled with water. The ORP sensor is one of the sensors that determine water quality so in the shrimp farming process it is very necessary. The use of the ORP sensor is intended so that shrimp farmers can easily get information on the state/quality of the water used as a medium for shrimp cultivation without having to do manual measurements/measurements by coming directly to the shrimp farming area.

Sensor testing, of course, cannot be separated from a microcontroller which acts as a component that processes data. The results of the ORP-ARMS sensor test are shown in Table 1.

Table 1. Comparative test results of sediment potential redox measurement data on ARMS Instruments with ORP Meter.

Treatment	Cultivation Media	the Amount of Shrimp	ORP value (ARMS) (mV)	ORP value (ORP Meter) (mV)	Difference (mV)
Treatment 1	Bucket 1	75	-15,79	-15,25	0,24
	Bucket 2		-10,43	-11,97	1,54
	Bucket 3		-17,02	-17,75	0,73
Treatment 2	Bucket 4	50	21,32	22,23	0,41
	Bucket 5		23,34	22,98	0,36
	Bucket 6		19,98	20,05	0,07
Treatment 3	Bucket 7	25	84,90	85,09	0,19
	Bucket 8		85,32	84,97	0,35
	Bucket 9		84,54	84,78	0,24

The test results shown in Table 1 are carried out by comparing the output value of the manufactured ORP sensor (ARMS) with the manufactured/conventional ORP measuring instrument (ORP Meter). The data in Table 1 is the measurement data carried out in the 6th week after the shrimp seedlings were stocked on the culture media. The results show that the difference between the two readings is in the range of 0.07 to 1.54. This means that the accuracy value of the ARMS instrument is very good because it has an accuracy value above 95%, which is close to the commercial ORP Meter.

Redox potential (Eh) itself is the relative value of the oxidation and reduction processes in the aquatic environment (Suwoyo *et al.*, 2014; Suwoyo *et al.*, 2015; Nadi *et al.*, 2019). Table 1 explains that larger values indicate more oxidized conditions expressed in millivolts (mV). Sediment potential obtained during the study ranged from -

17.02 to 85.32 mV with variations determined by different treatments for the number of shrimp. Treatment 3 had a better sedimentation potential value than the other treatments because the number of shrimp stocks was less.

The sediment condition at the bottom of the shrimp culture media is dominated by a reduction process that tends to be anaerobic. If no sludge is removed during the maintenance process, then the sediment redox value is far below the required value (ideally in the range of 50 mV to 100 mV).

During shrimp rearing, organic matter that accumulates at the bottom of the pond in the form of sediment will increase with the increasing age of rearing. This event is followed by a decrease in the redox potential and a decrease in dissolved oxygen. This decrease in oxygen is caused because oxygen is widely used for shrimp respiration, which continues to increase its biomass, decomposition of organic matter, and oxidizes other materials. The oxygen content in the sediment has a major effect on the potential redox value and the pH of the sediment, besides that it can also be used as a control for chemical reactions of ions between water and sediment. The amount of organic matter, the number of bacteria that live in the substrate, and the lack of water circulation cause the oxygen levels in the substrate to decrease. This situation can change the condition of the substrate into a reducing environment. This has an impact on the quality of shrimp when harvesting is done. The graph of the decrease in potential redox with the increasing age of shrimp rearing is shown in Figure 5.

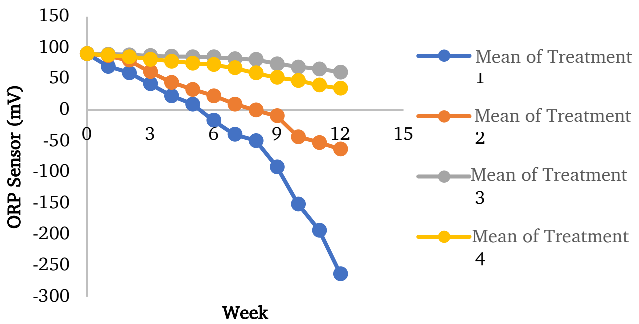

Figure 5. Graph of potential redox decrease with increasing age of shrimp rearing.

Monitoring Page Display on Smartphone

A smartphone is a cellular phone that uses services such as a built-in display, microprocessor, memory, and modem. That way, smartphones have more complete features than ordinary cellphones. In this study, a smartphone is used to monitor the results of the ORP sensor readings. Figure 6 (a) shows the display of sensor readings on a smartphone, Figure 6 (b), Figure 6 (c), Figure 6 (d), Figure 6 (e).

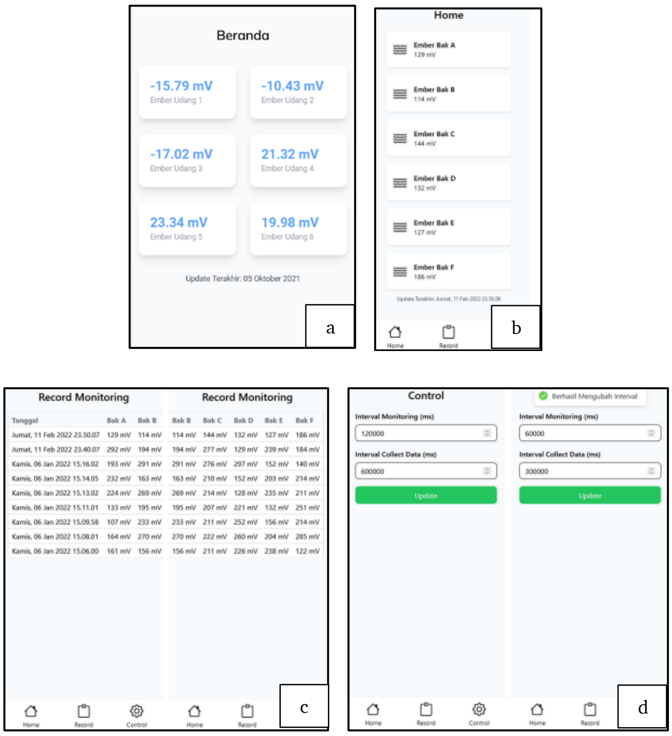

Figure 6. (a) Display of sensor readings on smartphone applications, (b) Display of Home menu, (c) Display of Record menu, (d) Display of Control menu.

When the user enters the main page, it will be shown as shown in Figure 6 (a). When pressing the Home button (Figure 6 (b)), the user will be shown a display of the oxidation value of each bath and the last time the value was updated. When pressing the Record button (Figure 6(c)), the user will be shown a table display containing the date when the data was received and also the oxidation value of each existing shrimp pond. This result set is stored in the database according to the time interval that can be set via the "Control (Figure 6 (d))" menu. However, if the hardware fails to get the latest time interval, the hardware will use the previous time interval value.

CONCLUSION

This study has successfully tested the sediment potential redox measurement system for the detection of shrimp pond water quality through remote monitoring using a smartphone for 12 weeks. The data stored through the men's record can be viewed and retrieved so that it can be reprocessed on an external apk. The results of the comparison of potential redox data between the ORP Meter sensor and ARMS obtained that the ORP sensor measurement accuracy on the ARMS instrument is above 95%.

ACKNOWLEDGMENT

We would like to thank Bogor Agricultural University for funding this research through research grants for young lecturers numbered SK: 9057/IT3.L1/PT.01.05/M/B/2021.

REFERENCES

Al Barqi, U., Santyadiputra, G.S. and Darmawiguna, I.G.M., 2019. Sistem monitoring online pada budidaya udang menggunakan wireless sensor network dan internet of things. *Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (KARMAPATI)*, *8*(2), pp.476-487. https://doi.org/10.23887/karmapati.v8i2.18682

Alfiansyah, M.W., 2020. Implementasi IOT untuk EWS menggunakan forecasting metode DES model holt pada tambak udang vaname. *Thesis*, Universitas Mataram.

Eridani, D., Widianto, E.D. and Kholid, N., 2020. Rancang bangun sistem monitoring dan controlling tambak udang windu dengan konsep internet of things menggunakan protokol message queuing telemetry transport. *Journal of Computer Engineering, System and Science*, *5*(1), pp.137-145. https://doi.org/10.24114/cess.v5i1.14718

Kusumah, B.R., Kostajaya, A., Supriadi, D., Nugraha, E.H. and Siskandar, R., 2020. Engineering of automatically controlled energy aeration systems for fisheries cultivation pools. *Aquacultura Indonesiana, 21*(2), pp.74-81. http://dx.doi.org/10.21534/ai.v21i2.207

Kusumah, B.R., Jaya, A.K., Iftitah, D., Siskandar, R., Lestari, H., Umam, K. and Supriadi, D., 2021. Penerapan teknologi tepat guna (e-ox level) kepada kelompok pembudidaya ikan lele di desa kepongpongan kabupaten cirebon. *Unri Conference Series: Community Engagement*, *3*(2021), pp.40-46. https://doi.org/10.31258/unricsce.3.40-46

Kusumah, B.R., Jaya, A.K., Siskandar, R. and Rahim, F.F., 2022. E-ox level: sustainability test of data storage system and performance test on closed system fish pond. *Aquacultura Indonesiana, 23*(1), pp.1-8. http://dx.doi.org/10.21534/ai.v23i1.267

Mardhiya, I.R., Surtono, A. and Suciyati, S.W., 2018. Sistem akusisis data pengkuran oksigen terlarut pada air tambak menggunakan sensor dissolved oxygen. *Jurnal Teori dan Aplikasi Fisika*, *6*(1), pp.1–50. http://dx.doi.org/10.23960%2Fjtaf.v6i1.1836

Nadi, M.R.G., Ruskandi, C. and Pamungkas, R., 2019. Rancang bangun alat monitoring air berbasis mikrokontroler dengan sensor kualitas air. *Journal Online of Physics*, *5*(1), pp.48–56. https://doi.org/10.22437/jop.v5i1.8245

Pauzi, G.A., Suryadi, O.F., Susanto, G.N. and Junaidi, 2020. Rancang bangun sistem monitoring kualitas air tambak udang (*Litopenaeus vannamei*) menggunakan wireless sensor sistem (WSS) yang terintegrasi dengan PLC CPM1A. *Journal of Energy, Material, and Instrumentation Technology*, *1*(3), pp.103–112. https://doi.org/10.23960/jemit.v1i3.34

Said, N.I., 2014. Teknologi pengolahan air asam tambang batu bara "alternatif pemilihan teknologi". *Jurnal Air Indonesia*, *7*(2), pp.119-138. https://dx.doi.org/10.29122/jai.v7i2.2411

Salfia, E., Azhar and Kamal, M., 2018. Rancang bangun alat pengendalian dan monitoring kualitas air tambak udang berbasis salinitas dan kadar oksigen terlarut. *Jurnal Tektro*, *2*(2), pp.24–29. http://e-jurnal.pnl.ac.id/TEKTRO/article/view/1630

Siskandar, R. and Kusumah, B.R., 2019. Control device engineering for aquaponic monitoring system. *Aquacultura Indonesiana, 20*(2), pp.72–79. http://dx.doi.org/10.21534/ai.v20i2.151

Suciyati, S.W., Hidayatullah, M.S. and Pauzi, G.A., 2021. An analysis of data acquisition system of temperature, oxygen, and carbon dioxide in refrigerator with arduino mega 2560. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *10*(1), pp.119–127. https://doi.org/10.24042/jipfalbiruni.v10i1.7452

Suwoyo, H.S., Nirmala, K., Djokosetiyanto, D. and Mulyaningrum, S.R.H., 2013. Dominant factors affecting sediment oxygen consumption level in intensive white shrimp (*Litopenaeus vannamei*) pond. *Jurnal Ilmu dan Teknologi Kelautan Tropis*, *7*(2), pp.639-354. http://dx.doi.org/10.29244/jitkt.v7i2.11031

Suwoyo, H.S., Undu, M.C. and Makmur, 2014. Laju sedimentasi dan karakterisasi sedimen tambak super intensif udang vaname (*Litopenaeus vannamei*). *2014: Prosiding Forum Inovasi Teknologi Akuakultur*, pp.327–339. http://ejournal-balitbang.kkp.go.id /index.php/fita/article/view/3062

Suwoyo, S.H., Tahe, S. and Fahrur, M., 2015 Karakterisasi limbah sedimen tambak udang vaname (*Litopenaeus vannamei*) super intensif dengan kepadatan berbeda. *2015: Prosiding Forum Inovasi Teknologi Akuakultur*, pp.901–913. http://ejournal-balitbang.kkp.go.id/index.php/fita/article /view/1914

Wicaksono, D., Bhakti, T.L., Taruno, R.B., Subroto, M.R.S. and Mustikasari, A., 2021. A galvanic-based dissolved oxygen level monitoring sensor system in freshwater ponds. *Jurnal Teknologi dan Sistem Komputer*, *9*(2), pp.83–89. https://doi.org/10.14710/jtsiskom.2021.13996