Integrated Online Water Quality Monitoring

An Application for Shrimp Aquaculture Data Collection and Automation

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***Abstract*—In this paper the design and realisation of an integrated online water quality monitoring system will be described. The system has been applied specifically to monitor the DO (Dissolved Oxygen) and pH parameters in several shrimp aquaculture centersin Indonesia.The aim was to reduce energy consumption and to create optimumwater condition for the shrimp aquaculture.Using an automatic aeration system, the DO value has been maintained above 5 mg/l.On the other hand, data collected from the sensor measurements at each aquaculture can be accessed by SMS gateway or transmitted to the master station using telemetric system for further analysis or study.**

***Keywords*—water quality; online monitoring; sensors; shrimp aquaculture; automation**

I. INTRODUCTION

In a shrimp aquaculture, maintaining good water quality is very important to ensure a healthy shrimp life throughout the period of the aquaculture (usually 100 days for vaname type shrimp) [1,2]. Although there are many water quality parameters involved, but the two most important ones are pH and DO parameters [3]. As a measure of the acidity or alkalinity of thewater,pH functions as an indicator for chemical and biological reactions in an aquatic environment. Whereas DO is an indicator for the water metabolism,that can be used to monitor organic as well as nutrient pollutants [4,5].

Conventional means of water quality monitoring at the shrimp aquaculture has always been performed by manually taking the water sample, and then analysing it in the laboratory [6]. A more advanced technique is sometimes by using hand held instruments to measure the water quality parameters periodically. Both methods have a disadvantage of being impractical, labor expensive, and highly subjected to human error. In addition, it lacks of sufficient data collection capability,which is important for future prediction and study of the water quality characteristics in the area of the aquaculture [7,8].

To maintain a high DO, shrimp aquaculture normally uses an aeration system utilising many rotary fans, each of which is highly energy consuming. Sometimes these rotary fans are operated continuously, especially near the end of the harvest period, and thus creating an expensive operational cost for the aquaculture [9].

To address the above problems, online water quality monitoring systems have been designed and implemented in several shrimp aquaculture centers in Indonesia.Compared with previous works conducted in China [7], India [10], and Malaysia [11], this system allows not only remote data collection,but also automation by which aeration is performed only when the DO value dropped below a certain threshold value.Also, some of the implemented system covered only a short distance wireless data communication (several hundred meters) [12], thus it lacks of the potential for global data collection.

Several of such systems will be integrated using a single master station. It has the advantage of not only improving the current aquaculture management, but also providing important data for future aquaculture business development. System design, realisation, and operational will be described in the following sections.

II. SYSTEM DESIGN AND REALISATION

The basic concept of the online monitoring system for shrimp aquaculture is shown in Figure 1. Central to the operation of the system is a datalogger, that serves three main functions. First, the data logger reads, displays, and stores the incoming data from the DO and pH sensor readout. Secondly, it does a continuous threshold checking for the DO value. Lastly, it maintains wireless data transmission with mobile phone or master station.The data being sent to the mobile phone include alarm signals.

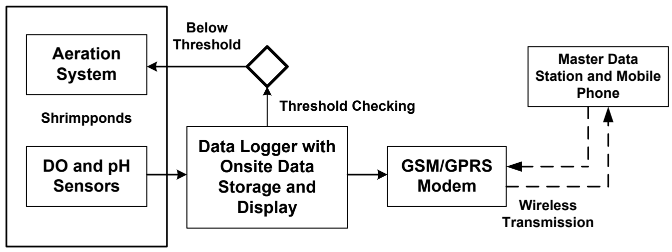

Fig 1. The concept of online water quality monitoring with automatic aeration system for shrimp aquaculture.

A. DO and pH Sensors

The DO and pH sensors used for this application are of analog encapsulated probe types, in which the outputs have been connected to sensor transmitters(Lutron TR-DOT1A4 for

DO and TR-pHT1A4 for pH)to avoid signal losses due to long wiring connection to the data logger.Using these transmitters, the output signals delivered by the sensorshave beenmaintained within the range of 4 – 20 mA, corresponding to DO values of 0 – 20 mg/L, and pH values of 0 – 14.The sensors and transmitters are then mounted on a PVC for easy placement in the shrimppond and to protect against external environment. The entire assembly can be seen in Figure 2.

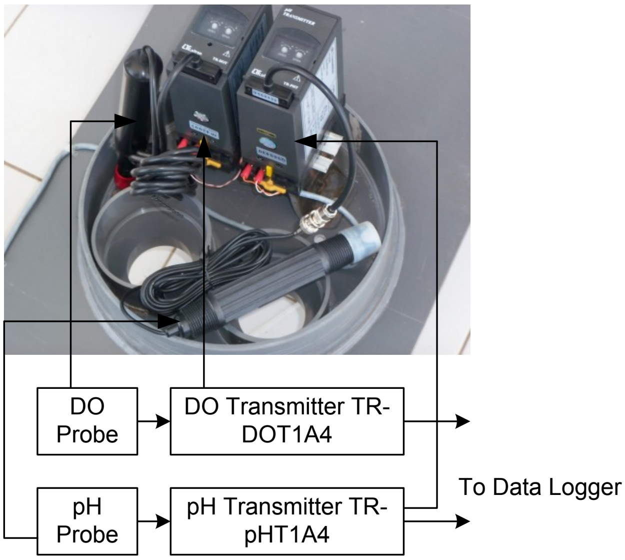

Fig 2. Connection and mounting of the DO and pH sensor probes and their transmitters in a PVC.

Sensor installation at the shrimppond must consider the point where the DO value might be the lowest. Thus if that area has a high DO, it can be assumed that other areas within the shrimpond must have a higher DO value. Normally, the lowest DO value accurs near the outlet of the shrimpond, because it is the most polluted by the food residual of the shrimp. Figure 3 shows the placement of the sensor and its PVC mounting near the shrimppond outlet (type 1).

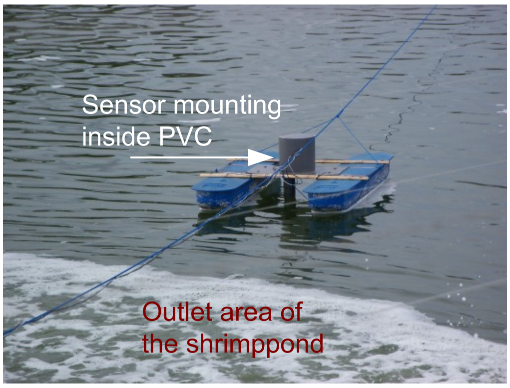

Fig 3. Installation of the sensor near the outlet of the shrimppond

In other variation, the sensor was installed inside a flowcell, by which the water was pumped using a submersible pump in to the cell, and the sensors thus measures the water quality parameters in a flowing condition (type 2). Figure 4 shows the configuration of the sensors inside the flowcell. Type 2 configuration has the advantage of avoiding the use of sensor transmitters and providing easy sensor maintenance, whereas type 1 avoids the use of a submersible pump thus reduces energy consumption.

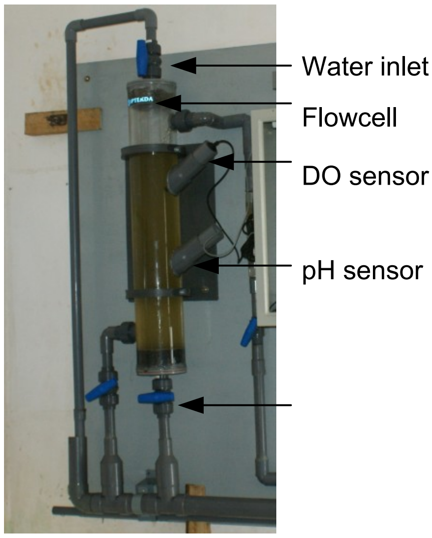

Fig 4. Sensor configuration inside a flowcell with water inlet and outlet, thus measurement can be performed in a water flowing condition

B. Data Logger

The data logger (Smart Datalog) used in this application has multiple sensor inputs (up to 8 channelswith 10-bit ADC (Analog to Digital Converter), CH0 – CH7), multiple relay output connections, and a GSM/GPRS modem interface. Figure 5 shows the layout of the data logger and its connections to the external components. The signals coming from the sensor transmitters are directly connected to the input channels of the data logger. The input channels can take analog or digital signals from the sensors, and so it does not require any additional signal processing interface at the input channels.The DO value has been set at CH0 whereas the pH value set at CH1, each having a measurement interval of 1 minute.

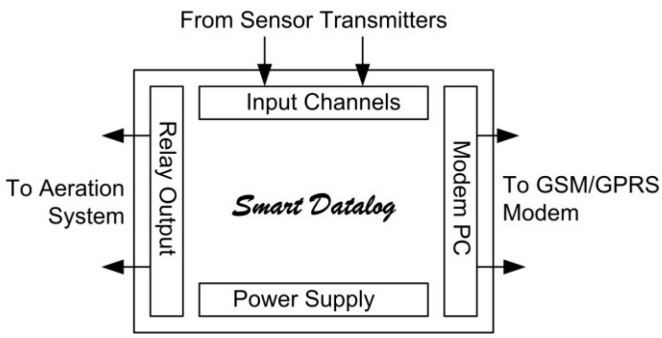

Fig 5. Layout of the data logger and its connections to the external components

The multiple relay outputs (8 channels) serve as the connection to the automatic aeration system. In this case, it is connected to the rotary fans through a separate switching panel. Each relay channel is programmable by setting which input channel correspond to a state level condition. In this case, CH0 has been set to state level 1 with the value of 5.00, meaning that if the DO reading from input channel CH0 is under 5.0 mg/L, it will activate the relay output 1. Likewise, if the reading from CH0 goes up beyond 5.0 mg/L, the relay output 1 will be deactivated. If the rotary fans have a speed selection mode, several relay outputs may be connected to different speed mode with different threshold value. Thus, as the DO values decline, the rotary fans will run faster.

Communication to the external system is done through a GSM/GPRS modem port of the data logger. In case of a DO or pH value dropped below a specific value, the data logger can send an alarm signal to a designated mobile phone through the modem. Conversely, the DO and pH data can be accessed anytime using a mobile phone.Figure 6 shows the setup of the data logger and the other components of the online monitoring system. The entire data logger was powered by a 12 V DC power supply, with a battery capable of providing 10 hours back up supply in case of electricity shut down.

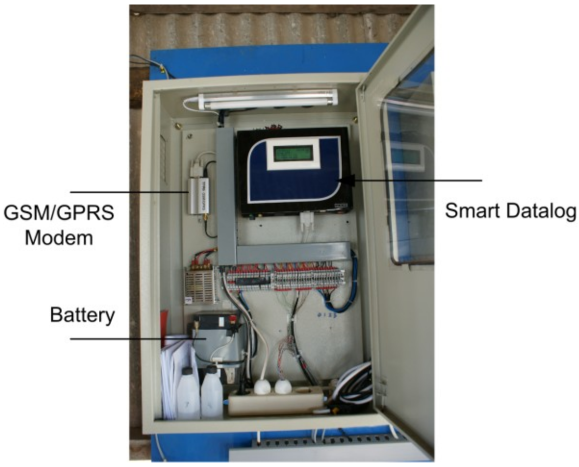

Fig 6. Setup of the Smart Datalog in connection to the other components of the online monitoring system

C. Automatic Aeration System

One of the main feature of this system is the automatic aeration method, which was designed to reduce the high electrical energy consumption due to excessive use of the aeration system. As can be seen in Figure 7, the aeration system on a shrimppond usually consists of 8 rotary fans, and in most condition, all fans will be operated continuously during the aquaculture period. Thus the idea is to selectively operate the rotary fans, either partly or non-continuously, depending on the DO value of the water.

It has been found that during the sunny day, usually the DO value at the shrimp aquaculture is high (above 8 on average). Thus operating many rotary fans in this condition will not have a significant impact in increasing the DO value.By only operating the aeration system during the night, or when the DO dropped below a certain level will obviously save electrical energy consumption. It is estimated that at least 30% electrical energy saving can be achieved if the aeration system is operated under such condition.

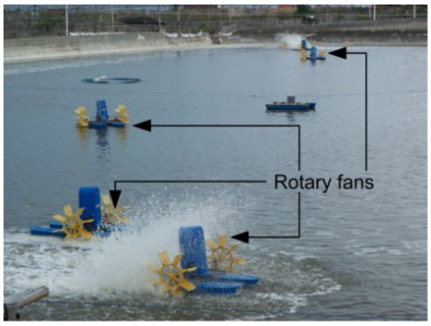

Fig 7. Aeration system consisting of many rotary fans operated automatically based on the DO value of the water

III. IMPLEMENTATION TOWARDS AN INTEGRATED ONLINE MONITORING SYSTEM

Shrimp aquaculture centersin Indonesia are located in Sumatra, Jawa, Bali, Nusa Tenggara, and Sulawesi. Each center has different water characteristics as well as different environmental condition, thus delivers different results from every season. However, they are managed by similar methodology. Despite the high demand and high economic value of shrimp commodity in the country, the development of shrimp aquaculture industry is rather slow. This is due partly to the lack of sufficient data related to aquaculture characteristics, which are important for future success of the business.

Fig 8. Location of the online water quality monitoring stations for shrimp aquaculture, ST1 (Banyuwangi), ST2 (Lampung), ST3 (Bali), and Master Station (Bandung)

Figure 8 shows the location of the online water quality monitoring stations. Starting in 2009, the online water quality monitoring system for shrimp aquaculture has been implemented in several places in Indonesia. The first system was implemented in Banyuwangi area (ST1), the eastern part of Java island. Then it is also implemented in Southern Sumatra (Lampung) (ST2) and Bali (ST3) island. In each location, water quality data has been stored and can be accessed by sms gateway.

The master station will serve as the database center of information from all stations, including the new ones developed in the future.Figure 9 shows the structure of the software database at the master station.Once the data has been stored, they can be displayed showing the station name and type (it can be integrated with data from water quantity stations), the time and date of the measurement, the period (at least daily) of data analysis, and graphical form of the data.

Fig 9. Structure of software database at the master station

In addition, from the master station it also allows changing of measurement condition on each station. As can be seen from Figure 10, each channel number of the data logger and the corresponding parameter to be measured by the sensor can be adjusted in terms of the measurement interval and alarm signal in case the measured parameter dropped below a certain level. Actually, the relay outputs of the data logger may also be adjusted remotely in terms of the state level and corresponding parameter value. Thus it gives full control of the automatic aeration system.

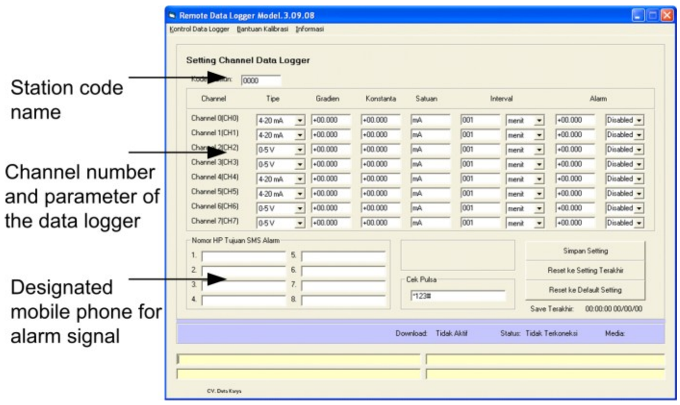

Fig 10. Changing of measurement interval and alarm signal can be performed by the software at the master station

IV. Conclusion

In this paper, the design and realisation of an integrated online water quality monitoring system has been described. The system has been applied to monitoring the DO and pH parameters in several shrimp aquaculture centers in Indonesia, i.e. Banyuwangi, Lampung, and Bali. Using an automatic aeration system, the DO value has been maintained above 5 mg/l. On the other hand, data collected from the sensor measurements at each aquaculture can be accessed by SMS gateway or transmitted to the master station using telemetric system for further analysis or study.The system has been operational in improving the water quality management and reducing the operational cost of the shrimp aquaculture. The integrated system is currently being developed to include new parameters and station from other location, as well as improved for better data transmission from the existing stations.

In the future, it is expected that such an online monitoring system can be implemented in all major shrimp aquaculture centers in Indonesia. The water quality data collected from each aquaculture center can then be integrated with other information such as water resources, business and geographical information, so that the database will serve as a decision supporting tools for the management of the aquaculture industry.

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