Wireless and Weatherproof Pond/Water Parameters Measurement System for Freshwater Aquaculture

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Abstract: This paper describes the development of "Wireless and Weatherproof Pond Parameters Measurement Systems". Fisheries industry has great economical value as they are a source for employment and revenue generation for the human. India is a rich country in terms of coastal area, rivers, water bodies etc., so there is a huge potential for fish production. In order to have a good production of fish, we need to maintain good water quality of ponds/lakes where the cultivation of fish takes place. This reflects the need for water/pond parameters measurement systems. Also the ponds are located in coastal regions/rain affected regions, which are prone to severe rains/intermittent rains throughout the year, so these pond parameters measurement systems should be rugged and water proof. Present rugged and weather proof systems available in the market are costly and require manual intervention during the measurement. They can measure the water quality up to certain distance only, due to limitation with length of the probe. Usually a skilled personal gather the water sample and test in laboratory offline or directly by latest water measurement handy instrument, but these methods are time consuming and tedious .

The paper present a battery operated wireless and weather proof pond parameters measurement system. The wireless connectivity helps in gathering the data without interrupting the system, once it is installed on site. The system is developed using Orion-5 Star meter and Zigbee wireless module. The measured water parameters are dissolved oxygen (DO), pH, Conductivity, Temperature, Pressure. The developed system is cost effective, compact and portable. The system weights less than 1.5 kg, so it can be installed on any floating structure in lager ponds. The system is enclosed in water proof box of size 380x280x130 mm. The advantage of this type of system, we can measure the water quality parameters wirelessly of the pond located anywhere 500 meters sq. meters area (restriction of depth only- up to 4 meters).

Keywords: *Water Parameters Measurement, Weatherproof, Zigbee, Aqua Culture*

1. INTRODUCTION

The rapid growth of population, the increase of production in manufacturing industry and the associated increase in pollution has focused considerable attention on the quality of effluent and drinking water, the condition of rivers and lakes [1]. Stringent laws have been passed to determine the presence and concentration of elements hazardous to health as well as to provide a mechanism to monitor the general quality of the environment [1]. Similarly fisheries industry has great economical value as they are a source for employment and revenue generation for the government in the rural areas [2]. Blue revolution is started, to increase the production capacity of our fisheries industry and also to introduce more science into the aquaculture production [3]. Blue revolution is the water equivalent of green revolution. In order to meet these requirements, there is a need for water quality measurement systems for water bodies like ponds/lakes/rivers etc. There are systems available in the range of single parameter measurements to complex systems with multiple measurements and other features. High accurate water quality measurement systems are also available, but they are generally used to confirm the regulatory compliances. These systems generally used for laboratory purpose, they are expensive and complex to use. Other important issues with the present water parameter measurement systems are we need to bring the water sample manually in a beaker or container, to the measurement system in Laboratory or made an arrangement to collect sample of pond/river water. These sampling arrangements require lot of investment in terms of valves, regulators, pumps, pipes etc., which can't be affordable by all fish farmers. Field based water parameter systems need human presence during the measurement. The above issues arises the need for portable weather proof water quality measurement systems with minimal human intervention during measurement.

In this paper we propose a portable, weather proof system which monitors the water parameters required for fisheries industry. This system can be installed on any mechanical platform of dimension 380x280mm in length and width. The system requires minimal human intervention during measurement. This system sends data wirelessly to the remote server. The developed system provides 0.5 to 1% accuracy in readings.

2. POND PARAMETERS

The important water quality parameters are dissolved oxygen, pH, conductivity, temperature, dissolved ammonia, dissolved CO_2 etc. There are no direct measurement systems available for nitrate and dissolved CO_2 measurements. So here we concentrated on only four parameters dissolved oxygen, pH, conductivity and temperature.

Dissolved oxygen: Dissolved oxygen is generated by diffusion of atmospheric (air) oxygen into the water, production of oxygen from photo synthesis by aquatic plants. Winds, waves and tumbling water in fast moving streams increase the rate of diffusion. Lack of dissolved oxygen can cause damage to the healthiness of fish [2]

pH: pH is a measurement of the degree of hydrogen ion activity in a sample. It is defined as the negative logarithm of the concentration of active hydrogen ions in gram moles per liter. In *labeo rohita* (rohu) fish life cycle the pH varies from 6 to 9.

Conductivity: Specific conductance or conductivity provides an estimate of the dissolved ionized solids in water. It is a non-specific method, as it is sensitive to some extent to all ions in the sample. Changes in the conductivity of the weather are usually indicative of a discharge or runoff of strong acids, bases or other highly ionized material. It is highly temperature dependent.

Temperature: Temperature of pond water is directly effects the growth of the fish. The optimum the temperature the growth rate is higher, the deviation of temperature from the comfort zone, will increase the chances of diseases to fishes.

3. SYSTEM DESCRIPTION

The pond parameters measurement system is developed around the Orion 5 star [4] meter. The block diagram of the monitoring system is as shown in Fig 1:

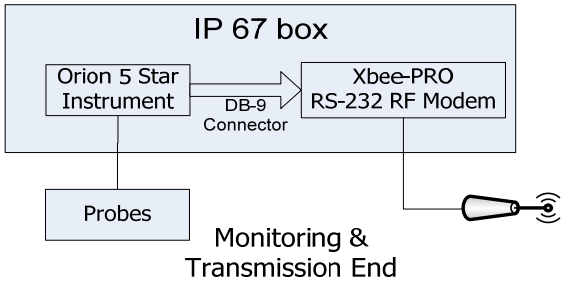

Fig 1: Block Diagram of Monitoring End

The system comprises of Orion 5 star meter, XBeePro [5] (Zigbee) trans-receiver modules, 9V battery, IP 67 PVC box, LabVIEW software platform and a PC.

The Orion meter measures dissolved oxygen, pH, conductivity and temperature with an accuracy of measurement 0.5 to 1%. Also it provides the features of auto calibration for each parameter. Apart from above the Orion meter also measures relative humidity, barometric pressure and ambient temperature for internal parameter compensation against environmental temperature and barometric pressure particularly for DO measurement. The Orion meter is programmed to measure all the parameters continuously and transmit those through serial port (RS-232 communication). The RS-232 output of the Orion meter is feed to the Zigbee wireless module to transmit data to PC using wireless connectivity up to 500 sq. meters area.

IP 67 waterproof PVC box is used to fit the system including the Orion Meter, Zigbee module and a battery. The system leak proof test was done by placing Orion meter, Zigbee module and the battery; inside the PVC box. Then talcum powder is applied on the inside walls of the box and box is closed. Now the box was immersed in a 25 liters water bucket and tested for 2 – 5 minutes. If there are any leaks, then the talcum powder will become wet and it can be easily detected by opening the box but, talcum powder found to be dry after the test and hence box leak proof test was confirmed.

Two through holes are provided one for Zigbee antenna mounting and the other for the sensor probes; these holes are provided on the bottom of the IP 67 PVC box. The holes are properly sealed using the rubber glands. At the receiving end Zigbee trans-receiver along with a PC/laptop was used to capture the data transmitted by the Orion meter.

The block diagram of the receiving end is as shown in Fig 2:

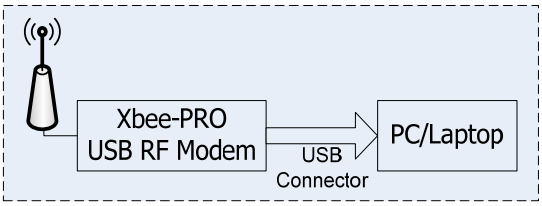

Fig 2: Block Diagram of Receiving End

LabVIEW based software is developed at the PC end to display, decode and store the data gathered from Orion meter for further analysis and decision support. The meter transmitter and the receiver modules are separated by at least 300-400 meters (aerial) distance apart, in line of sight to each other.

4. SYSTEM APPLICATION SOFTWARE

Orion meter is configured [6] such that it can carry out all the necessary measurements with minimum power requirements. The Orion meter can transmit the data in two formats, one is in longer format containing parameter name, values, units, coefficient, etc. while the other is in shorter format in which only parameter values are transmitted in order to reduce the transmission overhead, and hence saving the battery life. Most of the power consumption will be in the wireless communication rather than for the measurement. The meter can transmit the measured water parameters in a data packet for every 30 seconds. But to improve the battery life, the data transmission frequency to host PC (number of data transfers per day) can be kept at the optimal level as per the user requirement.

Fig 3: Developed System

The power supply to the Orion meter and Zigbee was provided through a 9V regulator connected to 12V Ni-Cd rechargeable battery. The output (RS-232) of the Orion meter is connected to the Zigbee module. The photograph of the developed system consisting of Orion Meter, Zigbee module, and battery embedded in the PVC box is as shown in Fig 3.

Zigbee receiver module is used to receive the transmitted data & it is connected directly to the PC (USB/Serial port). The data that available from the Orion meter may not be as per the user requirement. It may not contain the information like, date and time stamping, data unit, calibration factors etc., along with the measurement. Also there is a possibility of data packets lost during the wireless data transmission. In order to overcome these issues development of appropriate application software is necessary to ensure the correct data logging, control actions and data representation (graphical and numerical) as per the requirement of the user.

The flow chart of the application program is as shown in Fig 4. The application program starts with checking for com ports available in the system. The Zigbee module connected to the USB port will automatically assign a COM port. The com port list is displayed to the user for selection. If the appropriate com port is not selected, then system will generate an error after timeout. The com port selection screen is shown in Fig 5

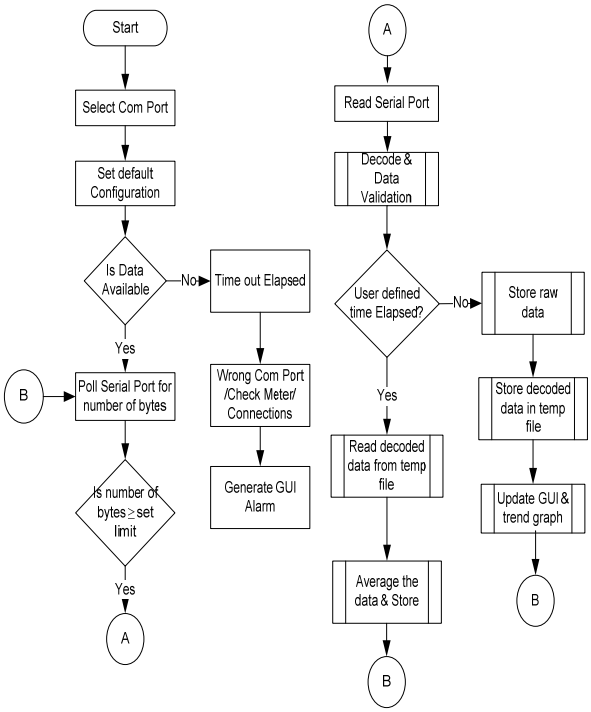

Fig 4: Flow Chart of Application Software

The basic requirements of the software are incorporation of error checking in the transmitted and receive data, decoding, validating and storing the data in a user defined file format for further processing. The application software is developed using LabVIEW platform. The features of the developed application software are: serial port selection, data receiving & decoding, initiate control actions, data packets lost during wireless transmission, data storage, alarm display, raw data storage, data packet received time, set points, limit settings for alarms along with trend and history graphs.

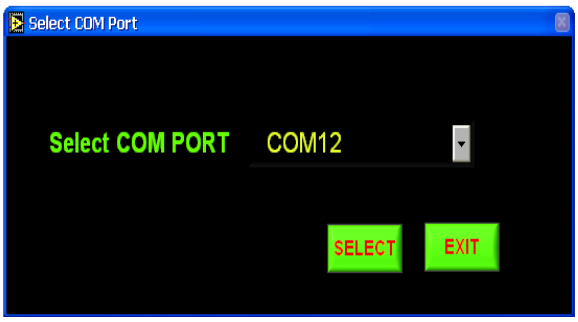

Fig 5: Com Port Selection

After selecting the port, the data is available for every 30 seconds on the serial port; using serial read function the data is read. The data available on serial port is in ASCII format. Now the received data will be validated, decoded and stored in a temporary file. Provision is given, for user selectable data storage time interval. In this feature the data will be stored continuously in a temporary file till user set time interval expired then, the data will be read from the temporary file; it is averaged and stored in a text file in **csv** format suitable for MS-Excel database software. The temporary file will be deleted after data is successfully stored in the main file.

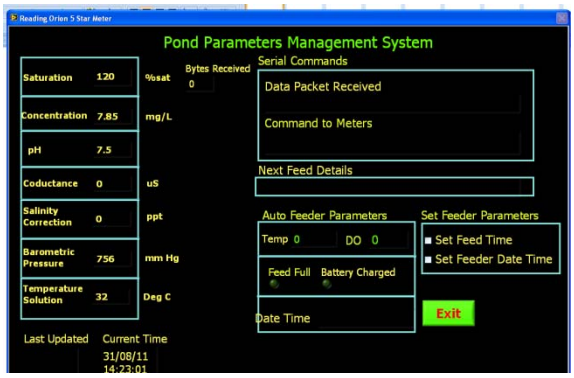

Fig 6: Main Screen of the Application Software

Both the decoded data and the raw data are stored in different files. The decoded data is stored with current date and time stamp along with the monitoring parameters. The raw data packet is stored with the date and time stamp as header and a carriage return as footer. Both these formats are stored in different folders to avoid any confusion. The main screen is updated with the decoded data. The application is developed such that similar pond monitoring systems can be easily networked. The mimic diagram of the monitoring software is shown in Fig 6.

User can set the alarm limits high limit and low limit for each individual measured parameter. After decoding the data, each individual parameter is compared against its high and low limits.

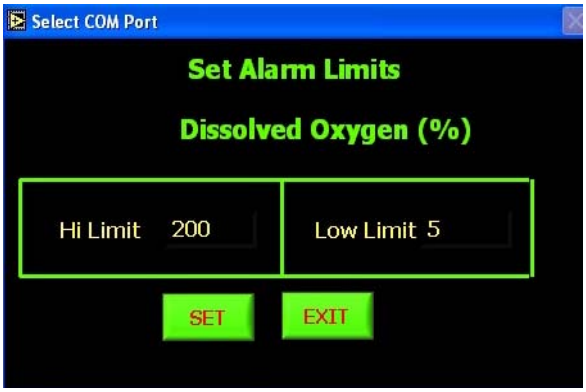

Fig 7: Alarms Set Screen

If the value is out of limits, then the visual alarm is generated in the display by turning the corresponding the value either to red if high or to yellow if low. If the value is within the limits then the display will be in green [2].

The raised alarms are stored along with the decoded data; the high alarm is stored as ‘H’ and the low alarm are stored as ‘L’. The user can log the data based on his requirement i.e., the user can select all parameters to log or any few parameters. The alarm settings screen is as shown in Fig 7.

5. RESULTS & CONCLUSION

The developed system is tested and successfully installed at CIFA Bhubaneswar, in August 2011. During the period from Aug 2011 to Sept 2011, Orissa received severe rains due to low pressure region [7] [8] [9]. System with stood the severe weather conditions and measured pond parameters. Below graph shows the variation of dissolved oxygen during a day.

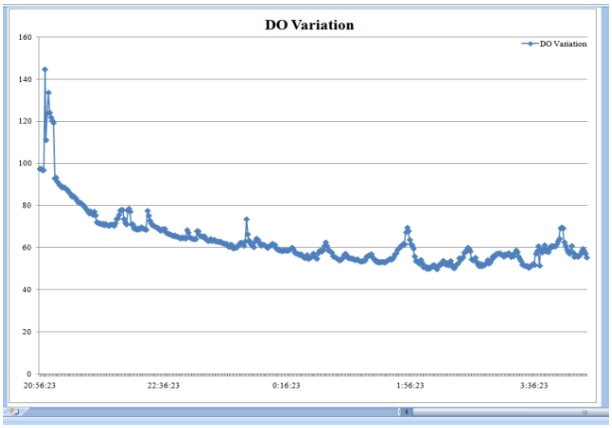

Fig 8: Variation of DO

The sample test data of the system is as shown in Table 1. The system provides overall accuracy of 0.5 to 1% over the parameter measurement range. Also the developed system is a cost effective, portable, weather proof and requires minimal human intervention during measurement and transmission the data wirelessly to the remote server.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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Table 1: Measured Pond Data

Time	Temp (°C)	Abs Pres (mbar)	pH	DO (% Sat)	DO (mg/l)	Conductivity (µs)
13:57:29	32.7	753.26	8.254	114.92	7.932	208.48
14:02:29	32.66	753.16	8.308	115.68	7.888	208.46
14:07:29	32.6	753.1	8.412	117.04	7.928	208.4
14:12:29	32.6	753.08	8.484	117.92	7.874	208.18
14:17:29	32.56	753.08	8.524	118.46	7.918	208.2
14:22:29	32.5	752.98	8.664	120.28	7.9	208.5
14:27:29	32.48	752.94	8.742	121.26	7.872	208.52
14:32:29	32.4	752.92	8.854	122.7	7.846	208.6