Utilization of Sensors and SMS Technology to Remotely Maintain the Level of Dissolved Oxygen, Salinity and Temperature of Fishponds

Rodrigo C. Munoz[a], Reynan P. Calderon[a], Rudy C. Flores[b], Sisenando C. Masangcap[c], Jayson P. Angeles[b] and Mark Colentava[a]*

[a] College of Engineering and Architecture, Bataan Peninsula State University (BPSU), Main Campus, Bataan
[b] BPSU Orani Campus, Bataan
[c] College of Business and Accountancy, BPSU Balanga Campus, Bataan
* rodmunoz@gmail.com

Abstract

Due to the occurrence of fish kills in various fish producing areas in our country, millions of pesos and opportunities for the Filipino people had been put into waste. Bataan Peninsula State University (BPSU) collaborated with the Central Luzon Association of Small-scale Aquaculture to devise strategies to address the said problem and prevent further losses.

More often than not, a fish kill can be attributed to the low level of dissolved oxygen (DO) in the water, decrease or increase in salinity and sudden increase in temperature, which usually occur after heavy rainfall, flooding or high tide, or high levels of ammonia due to decomposing organic matter and high temperature during summer.

For these reasons, BPSU researchers tested the use of radio frequencies and installed sensors in different areas of the fishpond at various depths to remotely monitor the levels of DO, salinity and temperature of the water. Once these reach critical levels, the installed system which comes with a specific program, will send an alarm through radio frequencies via Short Messaging Services (SMS) technology on the cellular/mobile phone of the caretaker or the fishpond operator. Upon receiving the alarm, caretakers were able to adjust the levels of dissolved oxygen, salinity and temperature of the water by remotely switching on the air compressor or the electric water pump using their cellular/ mobile phone, thus preventing losses due to fish kills.

Keywords: fish kill, dissolved-oxygen (DO), salinity, radio frequency, sensors

Introduction

The increasing activity of people affects the environment. Changes in the environment can be seen as part of climate change, from massive rainfall, floods, high tide, high temperature, etc. and these have brought about unstable production of food and food scarcity. The traditional way of maintaining the environmental conditions suitable for food production has not provided solutions to these present-day concerns which otherwise can be solved through precise and quick responses.

In 27 May 2011, the World Mind Network and the Batangas Fish kill Research Group reported a massive fish die-off in Taal Lake, Batangas. Over 800 metric tons of bangus and tilapia died in the areas of Laurel, Talisay, Tanauan City, and San Nicolas. In mid-June, more fish died, this time near Cuenca and Lipa City. More fish kills occurred until the month of July. In Taal Lake alone, the Department of Environmental and Natural Resources (DENR) reported that from 27 May until 8 June, 2,056 metric tons of bangus were counted as losses from 239 fish cages in 9 municipalities, and this amounted to P144 million. Fish kill losses in Taal Lake and Pangasinan have reached P190 million.

There were several theories to explain the die-off. The predominant one is that the beginning of the rainy season resulted in low oxygen levels in the lake. The problem with this is that the rainy season happens at almost about the same time every year, and yet fish kills like this one are very rare. A major factor is that there are still 14,000 fish cages in the Lake, even though the government in 2009 has put forth a regulation to reduce this to a maximum of only 6,000 cages.

Some believe that overfeeding of fish in commercial cages caused the die-off. Others hypothesized that increased emissions of hydrogen sulfide and sulfur from Taal volcano may be a factor. These were noticed during earlier fish kills.

Advanced technologies such as sensors and mobile phones lessen the need for people to be physically present in some activities so that they can spend more time in doing more productive things, and yet be assured that his/her job, company or business will still be managed efficiently through special monitoring and controlling facilities.

Objectives of the Study

The study aimed to develop an automated monitoring system with controlling facility using sensors and a database management system to remotely monitor the dissolved oxygen (DO), salinity and temperature of water in fish culture enclosures, particularly in ponds, thus preventing fish kills.

Specifically, it aimed to: 1) use wireless technology in maintaining the required level of DO, temperature and salinity in the fish production system; 2) prevent or at least lessen damages brought about by fish kills for sustainable food production; 3) create a program in the microprocessor that would give a preset environment condition in an automated aquaculture system as a solution to problems with regards to DO, salinity and temperature; 4) remotely monitor and maintain the DO, salinity and temperature for the species being raised in the fish ponds; and 5) assess its contribution to the aquaculture industry and fish pond operators.

Materials and Methods

The following were the factors considered in designing the project:

Installation – the server, the heart of the system, must be located in a safe and suitable facility near the location of the fish pond.

Flexibility – the system must be able to read, store, send, alter, manipulate and process the data from the program through the database.

Storage capacity – the server must have a high powered memory capacity.

Availability – the programming language used must be accessible in order to build a better database system.

Usability – it must be easy to use, understand, access and control.

Competitiveness – it must be able to help the various sectors in the fishery industry specifically, aquaculture by remotely monitoring and maintaining favorable environmental conditions.

A schematic diagram of the operational design for the automated monitoring system is presented in Figure 1. Meanwhile, the actual experimental setup layout is shown in Figure 2.

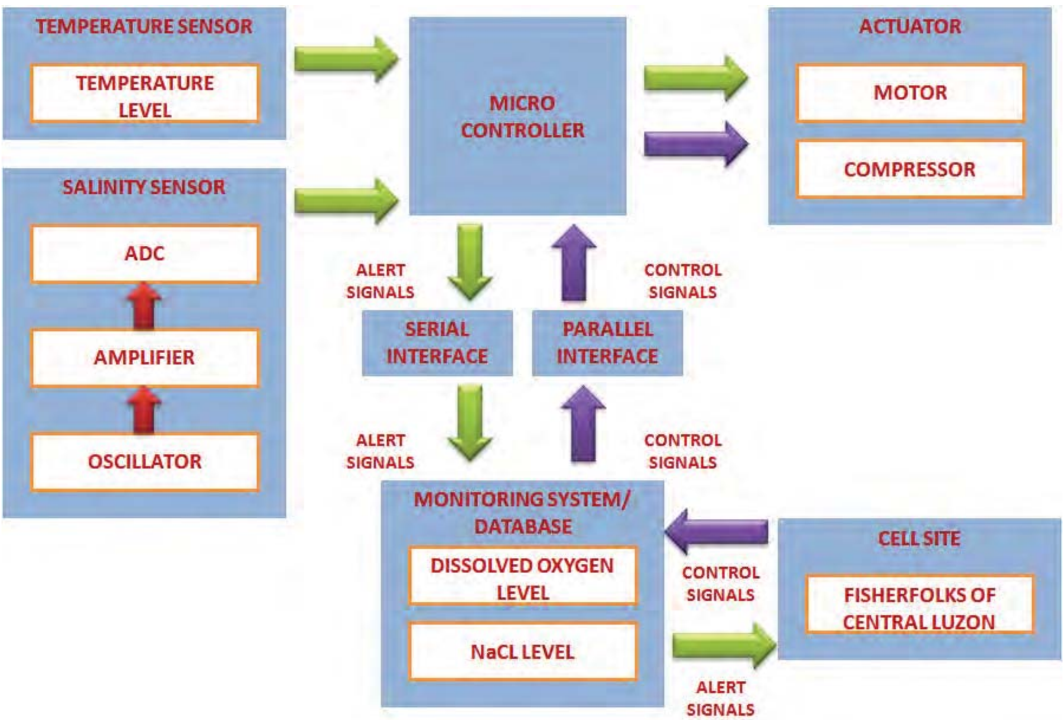

Figure 1. The operational design of the water monitoring and alarm system and how each component interfaces with each other.

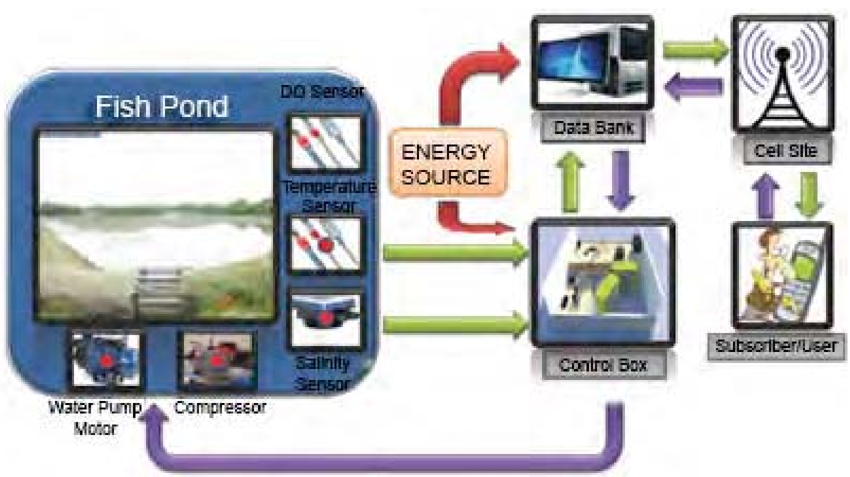

Figure 2. The layout of the experiment.

Results

Data on the levels of dissolved oxygen, salinity and temperature of the water in the experimental pond were successfully collected through the use of sensors and recorded in the micro controller unit (MCU) for analysis and interpretation, and transmitted via SMS to the mobile phone of the owner whenever a critical level had been reached. The compressor and electric water pump were also successfully switched on and off through the mobile phone of the owner even if he was not near his pond to adjust the DO, salinity and temperature of the water to desired levels. This means that the system could be a tool to remotely monitor and maintain a suitable environmental condition for the fish species being raised in the fishpond.

For temperature vs salinity, the data collected show that an increase in temperature will also cause an increase in salinity level making the relationship of the two parameters linear (please refer to Figure 3). The temperature versus DO, graph shows that DO content decreases as temperature increases (Figure 4). Finally, Figure 5 shows that when the value of salinity increases by 0.5, the dissolved oxygen decreases by approximately 0.02.

Discussion

The study proved that sensors and wireless communication systems can be used to remotely monitor the dissolved oxygen, salinity and temperature levels of water in the fishpond. It also proved that through the use of these advanced technologies we could also remotely manipulate and control devices and equipment such as air compressors and electric water pumps used in the fishpond, thus preventing fish kill.

Conclusion

Fish kill could be prevented if the levels of dissolved oxygen, temperature and salinity will not be beyond critical levels. This could be remotely monitored and manipulated through the use of sensors and wireless communication systems.

Table 1. Oxygen saturation at different temperature and salinity levels.

Oxygen Saturation Based on Temperature and Salinity										
Temperature (dec C)	Salinity (ppt)									
	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5
0	13.11	13.06	13.02	12.97	12.93	12.88	12.84	12.79	12.75	12.70
5	11.49.	11.45	11.42	11.38	11.34	11.30	11.26	11.23	11.19	11.15
10	10.19	10.16	10.13	10.10	10.07	10.03	10.00	9.97	9.94	9.91
15	9.14	9.11	9.08	9.05	9.03	9.00	8.97	8.94	8.92	8.89
20	8.27	8.24	8.22	8.19	8.17	8.15	8.12	8.10	8.07	8.05
25	7.54	7.52	7.49	7.47	7.45	7.43	7.41	7.39	7.37	7.35
30	6.92	6.90	6.88	6.86	6.84	6.82	6.80	6.78	6.76	6.75
35	6.38	6.36	6.34	6.33	6.31	6.29	6.28	6.26	6.24	6.23
40	5.90	5.89	5.87	5.85	5.84	5.82	5.81	5.79	5.78	5.76
45	5.47	5.46	5.45	5.43	5.42	5.40	5.39	5.38	5.36	5.35
50	5.08	5.07	5.06	5.04	5.03	5.02	5.01	5.00	4.98	4.97

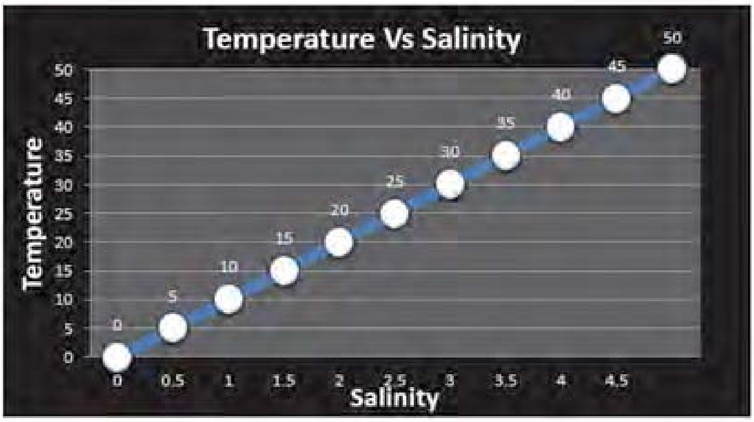

Figure 3. Changes in temperature and corresponding salinity levels in the experimental pond.

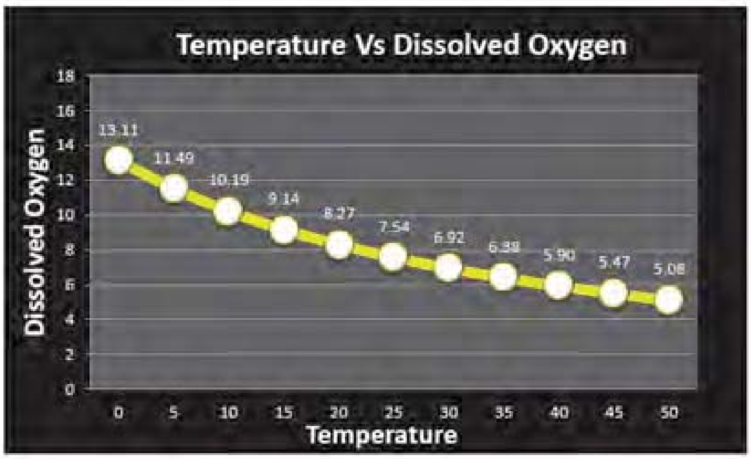

Figure 4. Dissolved oxygen and corresponding temperature levels in the experimental pond.

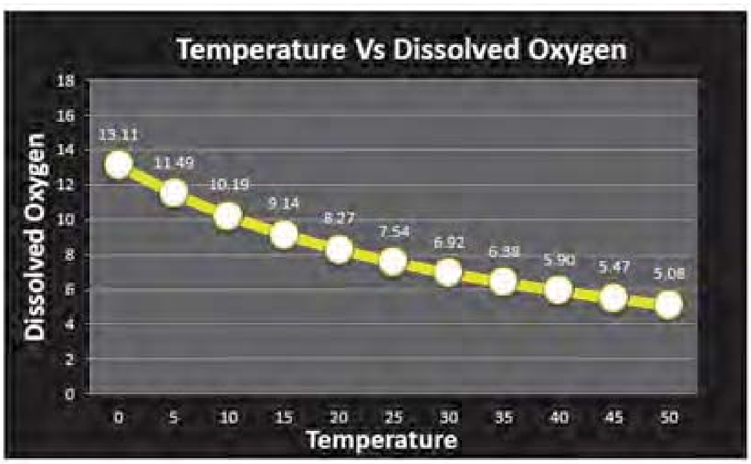

Figure 5. Dissolved oxygen at different salinity levels in the pond.

Recommendation

Fishpond operators could adopt this system to remotely monitor and control the condition of water in their fishponds, thus preventing losses due to fish kill. Similar studies could be made with other fish production systems such as those in Laguna and Taal Lakes, Pangasinan and other parts of the country affected by massive fish kills.

Suggested Readings

Fielding R, Irvine UC, Gettys J, Mogul J, Frystyk H, Masinter L, Leach P and Berners-Lee T. 1999. Internet RFC 2616. p 12.

Greenspun P. 2003. Database Management Systems. *In:* Philip and Alex's Guide to Web Publishing.

Hall EA. 2000. Internet Core Protocols: The Definitive Guide. O'Reilly and Associates, Inc. Sebastopol, California. p 9.

http://www.octiva.net/projects/ppm/.

http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZNTB201016080.htm (Schedule of Download- March 04, 2012).

http://en.wikipedia.org/wiki/Visual_Basic.

http://jwhiteassoc.com/BuoyAd.htm (Schedule of Download- March 04, 2012).

http://searchenterpriselinux.techtarget.com/definition/MySQL.

http://users.tkk.fi/virranko/greenhouse_mesa08.pdf (Schedule of Download- March 04, 2012).

http://www.campbellsci.com/ (Schedule of Download- March 04, 2012).

http://www.devarticles.com/c/a/MySQL/Introductory-Database-Theory-Systems-And-Design/.

http://www.ehow.com/facts_7834383_stranded-copper-wire-specifications.html.

http://www.fhwa.dot.gov/pavement/concrete/pubs/07019/chapt2.cfm (Schedule of Download- Nov. 15, 2011).

http://www.iaeng.org/publication/IMECS2010/IMECS2010_pp1046-1050.pdf (Schedule of Download- March 04, 2012).

http://www.oppapers.com/essays/Wireless-Monitoring-Of-Water-Level-Using/268573 (Schedule of Download- March 04, 2012).

http://www.projectsof8051.com/projects/24-monitor-and-control-of-greenhouseenvironment.html (Schedule of Download- March 04, 2012).

http://www.sensorex.com/support/more/dissolved_oxygen_technical_education.

http://www.wseas.us/e-library/transactions/control/2010/89-349.pdf (Schedule of Download- March 04, 2012).

ISRD Group. 2007. Chapter 11. Data Communication and Computer Network. pp 145-147.

Noah SA and Lloyd-Williams M. 1995. A selective review of knowledge-based approaches to database design. Information Research, 1(2).

Ramakrishnan R and Gehrke J. Database Management Systems, 2nd Edition.

Rosana M. 2008. Bureau of Fisheries and Aquatic Resources Inland Fisheries Research Station.

Tanembaum AS. 2003. Computer Networks. 4th edition. Prentice Hall, New Jersey. pp 421-427.

Williams HE and Lane D. 2004. Web database Applications with PHP and MySQL. O'Reilly & Associates, Inc. Sebastopol, California. p 748.