INTERNATIONAL JOURNAL OF COMPUTERS COMMUNICATIONS & CONTROL
ISSN 1841-9836, 10(4):471-479, August, 2015.

Efficient Design and Deployment of Aqua Monitoring Systems Using WSNs and Correlation Analysis

S. Babu Chandanapalli, E. Sreenivasa Reddy, D. Rajya Lakshmi

Suresh Babu Chandanapalli*
Associate Professor, Department of CSE,
Gudlavalleru Engineering College, Gudlavalleru-521356,
Andhrapradesh, India.
*Corresponding author: sureshdani2004@gmail.com

Dr E. Sreenivasa Reddy
Professor of CSE, ANU College of Engineering & Technology,
Acharya Nagarjuna University, Guntur-522510, Andhrapradesh, India.
edara_67yahoo.com

Dr D. Rajya Lakshmi
Professor, HOD of CSE, JNTUK University College of Engineering,
Vizianagaram- 535002, Andhrapradesh, India.
jrajyalashmi@gmail.com

Abstract: The roots of innovation are extending towards every field to provide ace solution. We cater an ace solution for aquaculture, where their yields (shrimp, fish, etc.) depends on the ponds water characteristics. The parameters depending on water must kept at certain optimal levels for better cultivation of Aqua. The parameters of water extremely project alterations during the day and also alter depending upon the environmental conditions i.e., it is necessary to monitor these parameters with high frequency. We adopt wireless sensor networks to monitor aqua forms. This system consists of two modules, they are transmitter and receiver station. We navigate data to database at receiver station through the GSM. The graphical user interface was designed in such a manner that the observations are forwarded to the farmer as message in their respective local languages to their mobile phones. That alerts them in unhygienic environmental conditions for adopting suitable measures.
Keywords: Aquaculture, wireless sensor networks, IAR-Kick, pH;

1 Introduction

Aquaculture is one of the widely extending industry attributable to the rapid demand for fish and seafood all over the world. The term aquaculture is referred as the cultivation of fish,plants and animals in various types of environments that includes rivers, ponds and oceans. Aquaculture consists of two types i.e. one is marine aquaculture that is nothing but the cultivation of species in ocean and another is freshwater aqua culture where species are cultivated in native water bodies. In shrimp culture, it is observed that samples that are taken into consideration to predict low levels in dissolved oxygen, temperature, salinity and PH levels. Taking all these parameters into consideration deploying sensors in shrimp culture for monitoring water quality and alert regarding contaminants in water will yield exceptional results. [1] [8]. The analysis of water quality desires consistent observation of water depended parameters in significant catchments. The various parameters which we consider as pH, dissolved oxygen, water temperature and water levels [2] at various depths. Making use of various ideal instruments like sensors and wireless sensor networks will produce better results. The adoption of Zigbee standard for short range and low cost module of wireless sensor network is developed in real time information system [3], in

which it consists of small sensor nodes, coordinator or gateway node and personal computer. In this system the smart sensor node monitor the ecological parameters such as water level, pH and dissolved oxygen and transmits it to the coordinator or gateway node from which data is again transferred to the personal computer where it is visualized for human-computer interface. The application of wireless sensor networks in various fields for detection of ecological parameters and transferring data to database using network. Yet, the wireless sensor networks have many constraints like memory, processing power and limited batter energy but the efficient utilization of energy is a decisive issue. We propose the implementation of wireless sensor networks to have a distributed collection of sensor nodes networked together to transfer the raw data to a central location known as base station through GSM. Every sensor node consists of a micro-controller, some sensors and a radio transceiver for communication [3]. The micro-controller is used for in-network processing for transferring needed information instead of raw data. The information which is transferred is preserved in a database and analyzed for further process. After analysis the data from database is forwarded to the farmers as a message to their mobile in their respective languages to alert them about the unhygienic environmental conditions. The proposed system makes farmers aware about the vulnerabilities so as to resolve them.

2 Motivation

Abrupt change in climate proves fatal for fish

G. Nagaraju

ELURU: The extremities in weather conditions delivered a deadly blow on Jampana Rama Raju, a fish farmer from Tedinadu village in Undi mandal of West Godavari district. Around 5-6 tonnes of the fish in his 100-acre pond worth Rs. 5 lakh died in the last two days due to deficiency in oxygen levels caused by sudden changes in the climate.

"I have just buried the dead fish in my fields. I could not have recovered even the fuel expenses had I brought them to the market at Akiveedu," he said.

According to Mr. Rama Raju, over 400 tonnes of fish died in his village alone in 2,000 acres of fishponds.

"It all happened when all the fish got ready for harvest and I was planning to catch them within a week," laments Mr Satyanarayana Raju who raised fish in a five-acre pond by investing Rs. 1.25 lakh per acre. He dumped the dead fish on the roadside.

The dead fish was sold at a price as low as Rs 2-5 per kg on Monday. The Akiveedu market receives 15-20 tons of fish from Krishna and West Godavari districts daily. The mortality was reported mainly in the Katla and Rohu species.

Heavy loss of crop was reported in Bhimadole, Akiveedu, Nidamarru and Bhimavaram areas.

V. Ramachandra Raju, president of the Delta Fish Farmers Association, said the reported inability of the district administration to provide canal water for agriculture in the rabi also played its part in ruining the fish farmers. The aqua farmers were forced to fill their ponds with drain water let out from the agricultural fields.

The wastewater contains parasitic loads of flukes and the other bacteria which take a heavy toll on the immunity levels of the fish when a drop in the DO (deficiency of oxygen) levels is reported, according to S.K. Akbar Ali, who runs an aqua lab at Akiveedu.

COLOSSAL LOSS: A worker displays the fish which died due to drop in oxygen levels in a pond at Akiveedu in West Godavari district. - PHOTO: A.V.G. PRASAD

Figure 1: Paper cutting for problems in aquaculture

In aquaculture, the yields(shrimp, fish etc) depends on the water characteristics of the aquaculture pond. Parameters must be maintained at certain levels for better cultivation of fish yields. The parameters asPH level, Salinity, turbidity, alkalinity and nutrition level alter from day and environmental issues. From early years, considerable amount of research and experimentation have processed in this field but till there is no perfect solution of this issue. There are certain possible wireless sensor network solutions that act as a perfect solution for the problem but to their drawbacks in power utilization, configuration, communication failures, environmental influences and scalability inspired us to perform further explorations in aquaculture. [1]. Fig.2.shown given below, Certain innovations those were carried out in aquaculture for their detection in 2011 the innovation of traceability enciphers for recirculation aquaculture and in 2012 creation of water checking framework where we adopt zigbee and GPRS for transmission of gathered data [4]. In this existing system we use a PH meter where we use a probe to testing the parameters and transferring the results using wireless sensor networks. In this manual testing there are some

drawbacks as arrangement of Ph meter at some frequency,maintains of probe, time for calculation of PH and manually testing is not possible in unhygienic environmental conditions. The earlier systems are not made up of GSM for aqua monitoring system for remote connectivity and sensing parameters.

Figure 2: Manual testing of PH

2.1 Proposed System Description

We propose the automatic system for checking water characteristics of aqua ponds in hygienic and unhygienic conditions. The proposed system consists of two modules, they are transmitter and receiver station and a personal computer which is used as analyzing station. The following list contributes overall framework of the aqua monitoring system:

- Embedded system design
- Radio frequency integrated circuits.
- Wireless sensor network.
- The collected data will be analyzed by using data mining tool.
- Convert the output into local language using local language.
- User interface design in local language

2.2 Design of transmitter station

We propose the implementation of wireless sensor networks to have a distributed collection of sensor nodes networked together to transfer the raw data to a central location known as base station through GSM. Every sensor node consists of a micro-controller, sensors and radio transceiver for communication. The micro-controller is used for in-network processing for transferring needed information instead of raw data. As the sensor node are powered by battery and thereby reduction of total n umber of bits will save the battery life. Research activities are

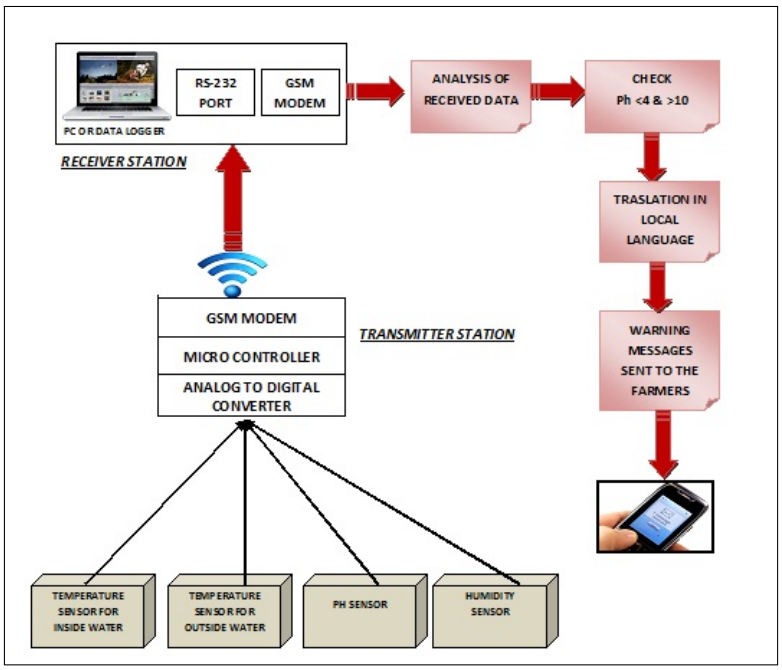

Figure 3: Overall architecture of aqua monitoring system

processing for the change of sensor node replacement for optimal coverage, topology formation, routing, data processing techniques to reduce communication costs, operating system design etc. it is also to estimate the impact of the present sensors in aquaculture as it needs few more crop cycles for generation of accurate results [6] [11]. In the proposed system, we introduce a sensor that makes use of the off-the-shelf available sensor nodes and we didnt make any specific efforts in hardware design cost reduction. The sensor is embedded in the transmitter station for monitoring of aqua forms depending on parameters like PH levels, dissolved oxygen levels, temperature inside and outside water, ammonia levels etc.The user interface was designed in VB and .NET. So that farmers and investigators may analyze and investigate the data. [7] The transmitter consists of: 1.Sensor nodes 2.GSM modems 3.Micro-controllers 4.ARM processor

2.3 Sensor nodes

Sensors are the electronic devices that sense the alterations of physical environmental conditions as sound, temperature, pressure etc.the sensor works at particular voltage and continuously transmit the signal in analog form. These signals are converted into digital form using converters. The sensors are of small size, consume low power and operate in high densities. We make use of following sensors:

- Temperature sensor for measuring the altering conditions of water
- PH sensor
- Humidity sensor.

Sensor selection

- Temperature sensor for outside water: we make use of DS18B20 I-wired digital sensor from maxim IC.

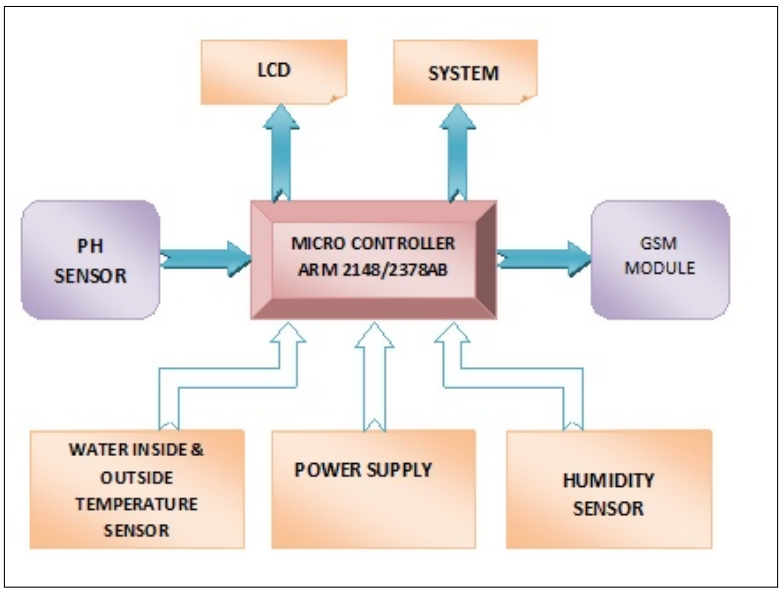

Figure 4: Block diagram of transmitter

- Temperature sensor for inside water: we make use of HOBO U-series sensor with UX 120-006M external channel data logger.
- pH sensor : we make use of a glass electrode for pH sensing.
- Humidity sensor : we use to measure the humidity.

GSM modems We make use of GSM modems for long range communication as the aquaculture ponds are far away to villages and the supply of power is not available to ponds therefore data collection nodes are not placed near to pond. We place the receiver node at data collection center in villages or towns and transmits message to the mobile phones with the help of a SIM, that supports 2G and g technologies, HSUPA, UMTS, WCDMA, HSDDA, GPRA and EDGE. These modems are embedded both at transmitter and receiver station.In this prototype we adopt AT89C52 micro-controller that is having the capability of showing high-performance by making use of CMOS-8 bit microcomputer having 8k bytes flash programmable and erasable read only memory.We make use of the ace ARM processor that comes with all the well known features and functionality.System software of the aqua monitoring system gains the sensor data and verifies with the data records and preserves the data in the database to construct a complete database. The constructed database consists of all the analyzed patterns depending on the altering environmental changes of fish ponds [5]. The sensor data is correlated with the ideal conditions present in the database. Any alteration in the ideal conditions will transmit a warning message to the farmer for adopting suitable measures. Communication process module is connected to the PC via serial port RS-232. We use IAR or RAM for controlling the wireless sensor system in the embedded software that is programmed in C. We port the hex document to the flash memory of AT-mega8 micro-controller via USB interface. The project is created with subroutine modules for sensor indicator digitization, engine transfer and value hand-off control, remote information procurement and transmission, universal and asynchronous receive transmit. The analog and digital converter of micro-controller performs cyclic scans for the sensors and considers the varying check rate that is programmable [9]. The sensor information might be contrasted and set-point qualities put away in memory. The transmission of information through the GSM to the base collector is done at serial correspondence at 9600 baud rate.

Tab.1. Technical specifications of communication protocol

Parameters	ZigBee	Bluetooth	Wi-Fi	GSM
Range	30m - 1.6 KM	30 - 3000ft	100 - 150 ft	30 - 35 KM
Power Consumption	0.2 mA(one node)	1 Watts	10.80 Watts	230 volts
Frequency	2.4G	2.4G	2.4G	900 and 1800 MHz
Cost	$350	$325	$500	$250

3 System implementation

The system was implemented in Gudlavalleru, Krishna district. The intensive aquaculture monitoring system is acquiring data from March-2014 to August-2014.this system analyzes all the appropriate operations and assesses the feasibility. We had taken a pond area of three acres and divided into four fish ponds. We deployed four sensor nodes and a transmitter node consisting of PH, Humidity and water temperature at the ponds. The whole system was tested appropriately with the connection of sensors to their modules and monitoring computer to its receiver nodes in the control room with the proper installation of sensor nodes in the fish ponds and their operations.

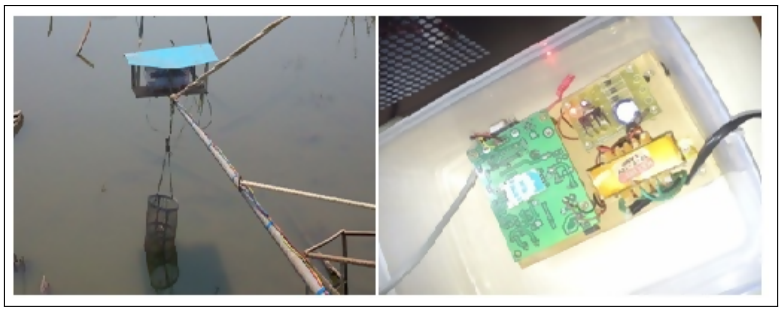

Figure 5: Installation of Transmitter station & Receiver Station at pond

4 Results and discussion

Tab.2. Summary of sensor data between Mar-2014 to July-2014

Parameters	Mar-14			Apr-14			May-14		
	Min	Max	Stdiv	Min	Max	Stdiv	Min	Max	Stdiv
*W. I.Temp.	23	26	2.12	23	25	1.4	18	22	2.83
**W .O.Temp.	25	27	1.41	25	25	0	25	26	0.7
Humidity	44.1	50.2	4.3	43.5	46	1.73	43.6	46.6	2.12
pH	6.1	6.3	0.14	5.8	6.2	0.28	5.8	6.2	0.28
Fish Mortality		1.4			1.1			1	

Parameters	June -14			July-14			Aug-14		
	Min	Max	Stdiv	Min	Max	Stdiv	Min	Max	Stdiv
*W. I.Temp.	22	24	1.41	23	23	0	23	24	0.71
**W .O.Temp.	25	27	1.41	25	26	0.71	25	27	1.41
Humidity	45.9	46.9	0.71	46.8	48.7	1.34	42	47.6	3.96
pH	5.8	6.3	0.35	5.7	6	0.21	5.7	7.8	1.48
Fish Mortality		1.2			1			1.3	

*-Water Inside Temperature **-Water Outside Temperature

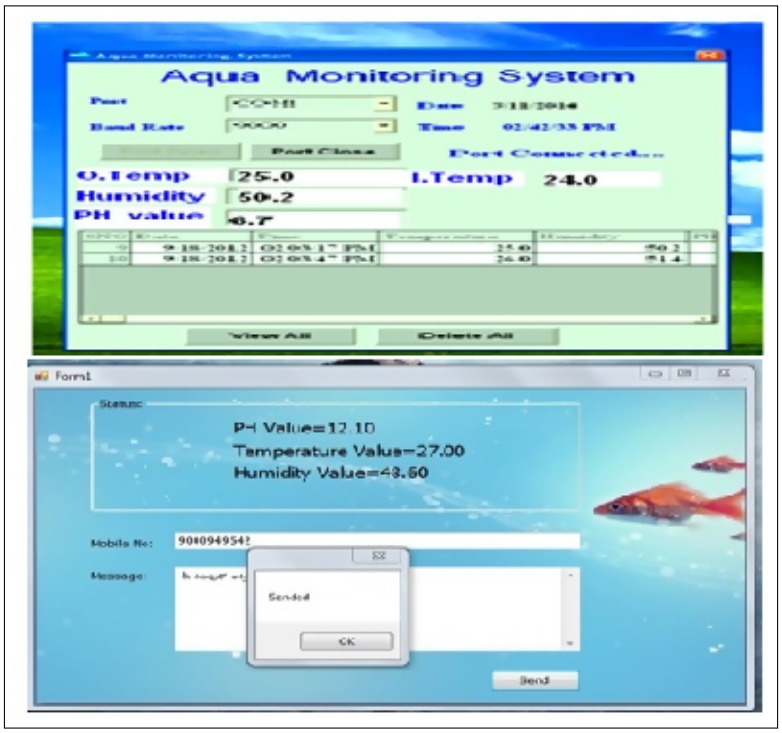

Figure 6: Monitoring screen and user interface of Aqua monitoring System

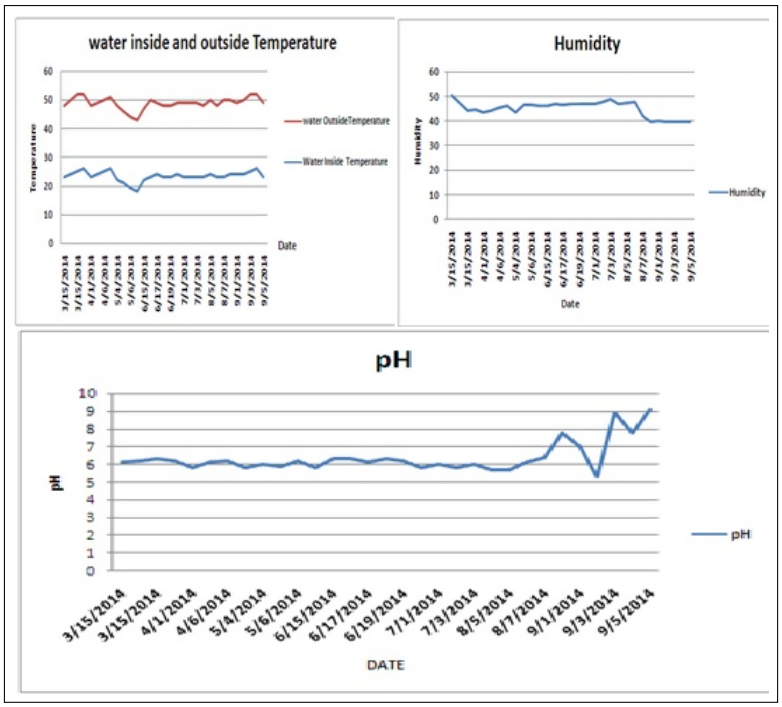

Figure 7: Water inside and outside temperature,Humidity,pH variation from a period of six months

Correlation Co-efficients

Correlation co-efficient may termed as the measure of the strength of linear association among two variables or parameters. The value of correlation always lies in between -1.0 to +1.0.if the value of correlation, C(r), is positive then we retrieve positive relationship, if negative we retrieve negative relationship [7] [10].

Formula:

$$C(r) = [N\sum XY - (\sum X)(\sum Y)]/Sqrt([N\sum X^2 - (\sum X)^2][N\sum Y^2 - (Y)^2])$$

Where,

N = The total number of values or elements
X = First Score
Y = Second Score
$\sum XY = Sumoftheproductoffirstand SecondScores$
$\sum X = SumofFirstScores$
$\sum Y = SumofSecondScores$
$\sum X^2 = SumofsquareFirstScores$
$\sum Y^2 = SumofsquareSecondScores$

Tab.3. Summary of correlation coefficients

Parameters	pH	Humidity	*W.I.Temp	**W.O.Temp
pH	1	0.75	0.85	0.95
Humidity	0.75	1	0.65	0.75
*W.I.Temp	0.85	0.65	1	0.70
**W.O.Temp	0.95	0.75	0.70	1

*-Water Inside Temperature **-Water Outside Temperature

Taking the available parameters in the table 3.i.e. pH, Water inside temperature, water outside temperature and humidity calculate the value for the variables X and Y.

5 Conclusions and Future Works

A wireless sensor network for aquaculture monitoring and control based on virtual instruments is presented. We implemented the hardware design of smart sensor nodes, transmitter/receiver with software design and prototype system of four sensor nodes with the embedding of transmitter/receiver with proper design structure. The collected data provides an accurate analysis of successful operation of the system. The proposed work can be utilized in various fields as greenhouse monitoring and control, hydrological water conservation and farm land irrigation. Future development efforts should involve enhancing the WSN by adding GPRS modules on the smart sensor nodes to monitor aquaculture environment on-line through the Internet. The monitoring program should be linked to the web server through a passive IP address in one port of the receiving computer, thus making the architecture more scalable and robust.

6 Acknowledgment

This work was supported by University Grants Commission - Minor Research Project for Teachers, Southern Eastern Regional Office, INDIA and is also sanctioned fund in-house R & D by Gudlavalleru Engineering College.

Bibliography

[1] http://www.nmfs.noaa.gov/

[2] A. Harun, D. L. Ndzi, M. F. Ramli, A. Y. M. Shakaff, M. N. Ahmad, L. M. Kamarudin, A. Zakaria, and Y. Yang (2012); Signal propagation in aquaculture environment for wireless sensor network applications, *Progress In Electromagnetics Research*, ISSN:1070-4698, E-ISSN:1559-8985, 131(1): 477-494.

[3] Zhuiykov S., Ertud K., Mirza I. (Eds.)(2010); Water Quality: Physical, Chemical and Biological Characteristics, *Sensors and Actuators B: Chemical*,ISSN: 0925-4005, Chapter 3 : 71-96.

[4] Wang, Xin; Ma, Longquan; Yang, Huizhong (2011); Online water monitoring system based on ZigBee and GPRS, *Proc. Eng.*, 15: 2680-2684.

[5] Tai, Haijiang; Liu, Shuangyin; Li, Daoliang; Ding, Qisheng; Ma, Daokun (2012); A multi-environmental factor monitoring system for aquiculture based on wireless sensor networks, *Sensor Lett.*, ISSN:1546-198X , 10 (12):265-270.

[6] D M. Razzemi, Z. Abdul Halim, M. Kusairay Musa and K. Hasbullah (2011); Development of Water Quality Monitoring System Prototype for Fresh Water Fish Culture, *Informatics Engineering and Information SciencE Communications in Computer and Information Science*, ISSN:978-3-642-25483-3 , 254(6): 470-478.

[7] Qi, J. Zhang, M. Xu, Z. Fu, W. Chen, X. Zhang (2010); *Developing WSN-based traceability system for recirculation aquaculture, Mathematical and Computer Modelling* PII: S0895-7177(10)00423-1, 53: 2162-2172.

[8] Bosma R. H., Verdegem M. C.J. (2011); Sustainable aquaculture in ponds: principles, practices and limits, *Livestock Sci.*, 139(1):58-68.

[9] Jose Juan Carbajal Hernandez, Luis P. Sanchez Fernandez, Oleksiy Pogrebnyak (2011); Assessment and prediction of the water quality in shrimp culture using signal processing techniques, *Aquaculture International*, ISSN:1573-143X, 19 (6): 1083-1104.

[10] Anita Bhatnagar, Pooja Devi(2013); Water quality guidelines for the management of pond fish culture, *International Journal of Environmental Sciences*, ISSN:0976-4402, 3(6):1981-2009.

[11] Glasgow H.B et al.(2004); Real-time remote monitoring of water quality: are view of current applications, and advancements in sensor, telemetry and computing technologies, *Journal of Experimental Marine Biology and Ecology*, ISSN: 0022-0981, DOI: 10.1016/j.jembe.2004.02.022, 300:409-448.