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ANALYSING THE WATER QUALITY PARAMETERS FROM TRADITIONAL TO MODERN METHODS IN AQUACULTURE

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Abstract: The water pollution in aquaculture has become a common problem. The monitoring of water exchange in aquaculture tanks is very important to monitor the welfare of fish (10). The conventional monitoring methods involve the manual collection of water samples from different locations. These samples are tested in the laboratory using the rigorous skills. Such methods are time consuming and are not efficient. The old method of quality detection and communication is time consuming, low precision and costly. Moreover, the current methodologies include analyzing various kinds of physical and chemical parameters. Therefore, this paper deals with the survey of water quality parameters in both traditional and modern methods. Automated sensor-based water quality monitoring are the best method for monitoring the water quality parameters in remote location. The system consists of various sensors such as temperature sensor, pH sensor, conductivity sensor, gas sensor, Dissolved Oxygen sensor connected with the notification node which includes microcontroller, LCD and buzzer to indicate the user in terms of any anomalies. This modern method helps in automization of analysing the water quality parameters in aquaculture

Keywords: Automation, sensor, microcontroller, Xigbee, mobile application, buzzer.

1. Introduction

Water is a universal solvent of chemicals and physical attributes affecting them combinedly contribute the water quality (2). Water quality monitoring is a important parameter in aquaculture monitoring. It depends on the elements present in the water goes beyond the tolerance level, then the water quality get affected (9). The parameter for environmental water quality and aquaculture water quality differs by its platform. The good quality of water differs from species to species. Shortage of clean water supply (4) and insuffcient waste removal lead to overloading of metabolites, environmental degradation, the organisms becoming stressed by bad water quality and it is affected by diseases (6). Important water quality parameters to be considered for analysing are temperature, salinity, pH, DO, ammonia, nitrite/nitrate, hardness, alkalinity and turbidity. In the bigger system of aquaculture ponds the three major parameters are likely to change drastically at open level. It

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will create adverse effect when the system is operatered in out of range. They are temperature, Dissolved Oxygen, pH and there comes a need of monitoring in continuous basis. In order to grow fishes in a healthy environment temperature is to be monitored continuously.

2 Traditional methods

In olden days Traditional methods have been followed to access the water quality parameters. The important water quality parameters are Temperature, pH, Dissolved Oxygen, ammonia, Nitrate, Nitrogen, Total Dissolved Solids. Sampling and monitoring of water samples are the age-old methods need in the past decades. Sampling could be defined as a process of selecting a portion of volume of sample to be transported and handled in the laboratory. The main di□culties in sampling are carrying out the samples to the laboratory. Many people think that the analysis starts when the sample arrives in the laboratory. The error possibility involved in sample preparation is high than anything else.

2.1 Determination Of pH by Potentiometry Methods

The potentiometric pH involves determination of activity and hence concentration of hydrogen ions using reference and glass electrode. A reference electrode is coupled with glass electrode, the difference in emf developed by the glass electrode is measured by the pH meter. It is calibrated to the pH reading directly. The apparatus consists of Potentiometer, glass electrode reference electrode and temperature compensating device. Both the electrode is incorporated into a single probe. It is called combination electrode and most commonly used electrode is calomel (reference electrode). The glass electrode consist of HCL in the thin walled bulb glass, when dipped in water the outer layer of glass bulb is hydrated forming swollen layer. The ion exchange between swollen layer and H^+ ions in the emf is calculated as pH.

2.2 Determination of Alkalinity

Alkalinity is used to measure the acid neutralizing capacity of water. Alkalinity is used to maintain constant pH level. Level of pH depends on hydroxyl, carbonate and bicarbonates ions present in the water. The natural water acts as a buffer solution and it is controlled by hydroxyl, carbonate and bicarbonate ions present in water. Alkalinity is highly helpful in maintaining the aquatic health of the fishes. If the level of alkalinity is higher, the taste of water gets affected. The main principles of alkaline water are reaction between alkalinity and cations present in water. The alkalinity of water can be calculated by the titration method with the water sample with sulphuric acid, phenolphthalein, mixed indicator, methylred,

ethylalcohol and distilled water. Total Alkalinity is calculated using the following formula (11).

$$Total\ Alkalinity = \frac{(volume\ of\ H_2SO_4) \times Normality \times 50 \times 1000}{volume\ of\ the\ sample} \quad (2.1)$$

2.3 Chlorinity Titration method

Mohr method is the Chemical method used for determination of halide content by titration and determining of the salt content present in the water. It consists of titrating a sample of water with silver nitrate solution of known concentration to the point where all halides (chloride plus a small amount of bromide) have been precipitated as silver halide, as detected by suitable indicators or electrode systems. A 15ml Knudsen pipette is used to measure the water sample into the titration vessel. This pipette di□ers from the standard type in that, after filling, the volume of sample is defined by rotation of a 3-way stopcock fitted at the upper end. Hence by Eq. (2.2) the chlorinity is calculated.

$$Cl_u = \frac{Cl_s \times T_u \times W_s}{T_s \times W_u} \quad (2.2)$$

2.4 Determination of Carbon-dioxide in water

In order to determine carbon dioxide levels in a solution, titration is done with sodium hydroxide. The carbon dioxide in the solution will react with the sodium hydroxide to form sodium bicarbonate. Phenolphthalein is used as indicator to determine the carbon dioxide in the water.

2.5 Determination of Hardness, Calcium and Magnesium in water

Hardness of water is determined by Ca^{2+}(aq) and Mg^{2+}(aq), ions chelating agent, ethylene diaminetetraacetic acid (EDTA), usually in the form of disodium salt (H_2Y_2) can be used as titration agent. At pH 10, Ca^{2+}(aq) ion first complexes with the indicator as CaI_n^+(aq) which is wine red. EDTA is added, as the stronger ligand the CaI_n^+(aq) complex is replaced by the CaY_2 (aq) complex which is blue. The end point of titration is indicated by a sharp colour change from wine red to blue. Eriochrome Black T is used as indicator which determines total hardness. Hardness due to Ca^{2+}(aq) ion is also determined by a separate titration at a higher pH, by adding NaOH solution to precipitate $Mg(OH)_2$(s), using hydroxy naphthol blue is used as indicator.

3 Laboratory Instrumental methods

The titration method was time-consuming and followed in earlier days to test the water samples from the farms to testing in laboratory and the titration results cannot be determined in the same day. The laboratory instruments methods are followed with wheat stone bridge

as in Fig. 1 to calculate the alkalinity in water. In this method, the time is saved and the results are given to the customer within few hours in the same day.

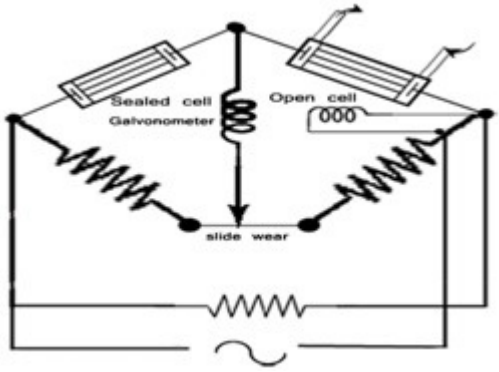

Figure 1: Weibel-Thuras Conductivity ratio measuring

But the difficulty lies in carrying the samples to the laboratory without contamination. In the kit method testing are carried by the use of salinometers to check the electrical conductivity of the sample and it is compared with the standard (IAPSO Standard Seawater) of known salinity at the same temperature. The measured conductivity ratio is converted to the practical salinity by means of the equation of PSS-78.

3.1 Atomic Absorption Spectrophotometer

Atomic Absorption Spectrophotometer (13) is an advanced method used in the laboratory to analyze the trace elements, nutrients and major irons. This technique involves detailed analysis and the methods are highly reliable. The principle involved is a sample is kept in the flame and light source is directed to the sample into monochromator (12). The detector measures the amount of light absorbed by the atomized element. Each element has its own wavelength. The principle is the amount of energy absorbed in the flame is proportional to the concentration of element in the sample. There is also a possibility of chemical interferences occurance when the flame is not hot enough to dissociate the molecules. This can also be overcome by adding specific elements. Higher absorption and errors can also be corrected and avoided (1).

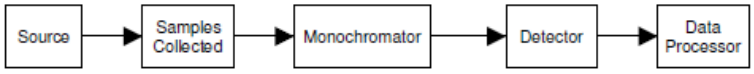

Figure 2: Flow of Atomic Absorption Spectrophotometer Method

4 Architecture of Sensor Based System in Aquaculture

The entire monitoring architecture consists of sensors for monitoring the parameters such as water quality, fish behaviour and fish feeding pattern. In this system 10 parameters are monitored inside the node boxes. All the box nodes are connected to the Access points using

WiFi technology and a low power Wireless Sensor Node are needed for continuous monitoring (14; 5). The Access points are connected to a switch with Ethernet line. The Access point is used to send the data to the farmers in-case of any anomalies and generated through alarming pattern. The farm managers/owners can make a request to database from anyplace/anytime and access the data. The sensor contains three box nodes.

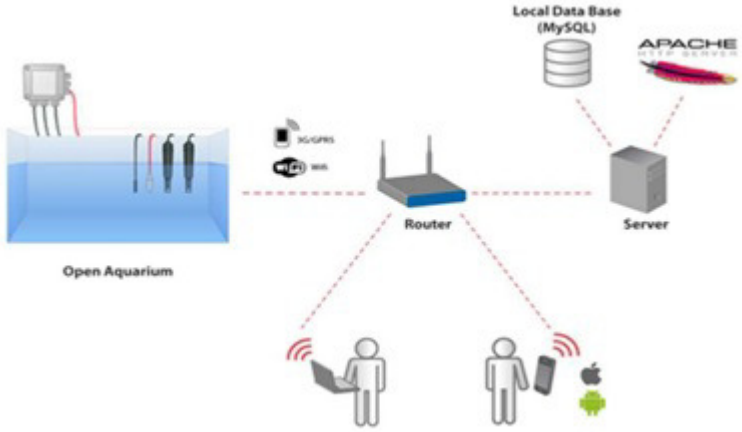

Figure 3: Automation System Overview

Table 1: Inference of water quality parameters

Parameters	Chemical methods	Automation techniques
Temperature	Lab Testing	Temperature Sensor LM 35
pH	Titration method	pH electrode generates voltage and connected to the sensor module
Conductivity	Chemical method and equations PSS-78	Conductivity sensor
Alkalinity	Titration method and Wheat stone bridge	Conductivity Sensor
Dissolved oxygen	Titration method and Lab testing	Dissolved oxygen probe interfaced with electronic control system
Ammonia	Titration method and Lab testing	Ammonia sensor mq135 sensor
Water flow	manual methods	Water flow Sensor to find the flow rates

The box node 1 is connected to the illumination, water level, oil layer, workers and fish behaviour sensors. The box node 2 consists of water quality sensors such as temperature, pH, turbidity and conductivity sensor. The box node 3 consists of feed fallen detector. The nodes sense the data and send to the database and the smart algorithm works on database for data recovery. If the algorithm concludes that the data sent is correct no further action is taken,

the data is just recorded for specific intervals. If the algorithm concludes that the data sent is incorrect, the alarm settings are made on with the smart algorithm. To avoid the energy waste in the sending data the smart algorithm is designed in the way to detect the necessary data (7; 10). First the threshold value for each variable is set. Sensor gathers and save the data as the reference value. If the data value is equal to the threshold value or lesser the values will be stored in the database. If the value is higher the alarm and notification via database is sent to the farm owners (10). Power consumption is the main factor of wireless sensor networks and it should be less so that the sensors can be used for more time. The application which has lower power cannot operate on Bluetooth. Turning on and off consumes a great amount of energy. In contrast, the ZigBee protocol gives importance on power management; it was developed for low power consumption and years of battery life. Bluetooth devices have lower battery life than ZigBee. Also, it provides higher network flexibility than Bluetooth, allowing different topologies (8).

5 Conclusion

The manual monitoring of water quality parameters in Aqua Farms/Hatcheries does not give the exact values and the process are time consuming and need more man power. The automated water quality parameters are monitored by the sensors and the data results are more accurate and quick remote access is possible. The temperature sensor are designed with LM 35. The pH sensor are made up of glass electrodes and yielded accurate results. The conductivity sensor are designed with two electrode method. The signal conditioning circuit yield good results. The gas sensor observes all the dissolved gases such as Ammonia, Nitrates, etc and the sensor can be calibrated based on our requirement. The Dissolved oxygen sensor tells the exact value of dissolved oxygen in parts per million. These are connected to the measuring node with microcontroller and the measurement's are transmitted by the wireless modules XBee modules by peer to peer communications. A notification node consists of microcontroller, LCD and buzzer for displaying the water quality parameters. The water quality parameters can be eye watched and anomalies are reported to the Farm/Hatchery managers. All the datas are stored in the database and accessed by a dedicated server. The time interval is set for the each data storage. The farm manager can access data from the database any time anywhere. The data are connected with the Ethernet shield and connected to the domain. The data can be transferred into a mobile application. The remote access of water quality analysis can also be monitored via mobile applications.

The sensors available in market are expensive and the best way is to design the sensors for analyzing the water quality parameters.

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