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Smart Aqua culture monitoring system using Raspberry Pi AWS IOT

Kamuju Sai Divya(15221D5509)
and Asst Prof V Sandhya
BVC ENgineering College,Odalarevu
AP,India

Roja Manchala
ECE,Asst Professor
Ellenki Educational Society
Hyderabad, Telengana, India

Sanju kumar N T
Embedded Application Engineer
iPROTECHS-Hyderabad
Telephone: +91-8367394636

Abstract—The Optimum fish production is totally dependent on the physical, chemical and biological qualities of water to most of the extent. Hence, successful pond management requires an understanding of water quality. Water quality is determined by variables like temperature, transparency, turbidity, water color, carbon dioxide, pH, alkalinity, hardness, unionized ammonia, nitrite, nitrate, primary productivity, BOD, plankton population etc. In the present chapter water quality management principles in fish culture have been reviewed to make aware the fish culturist and environmentalist about the important water quality factors that influence health of a pond and are required in optimum values to increase the fish yields to meet the growing demands of present day scenario of the world, when the food resources are in a state of depletion and the population pressure is increasing on these resources.

Index Terms Aqua Sensors, WSN, AWS IOT.

I. INTRODUCTION

Fish is an inexpensive source of protein and an impor-tant cash crop in many regions of world and water is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005). Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983). Many workers have reported the status of water bodies (lunatic and lotic) after receiving various kinds of pollutants altering water quality characteristics (physical, chemical and biological). All living organisms have tolerable limits of water quality parameters in which they perform optimally. A sharp drop or an increase within these limits has adverse effects on their body functions (Davenport, 1993: Kiran, 2010). So, good water quality is very essential for survival and growth of fish. As we know fish is an important protein rich food resource and there has been sharp increase in demand of fish products due to increasing population pressure in this century. Thus to meet the demand of present food supply, water quality management in fish ponds is a necessary step that is required to be,taken,up.

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In most of the countries, fishes are cultivated in ponds (lentic water) but unfortunately such culturists are not so aware of importance of water quality management in fisheries. If they are properly guided and make aware about water quality management practices, they can get maximum fish yield in their ponds to a greater extent through applying low input cost and getting high output of fish yield. The role of various factors like temperature, transparency, turbidity, water color, carbon dioxide, pH, alkalinity, hardness, ammonia, nitrite, nitrate, primary productivity, biochemical oxygen demand (BOD), plankton population etc. can't be overlooked for maintaining a healthy aquatic environment and for the production of sufficient fish food organisms in ponds for increasing fish production. Therefore, there is the need to ensure that, these environmental factors are properly managed and regulated for good survival and optimum growth of fish. The objective of the present chapter is to review and present a concise opinion regarding the optimum levels of water quality characteristics required for maximum fish production.

Block Diagram

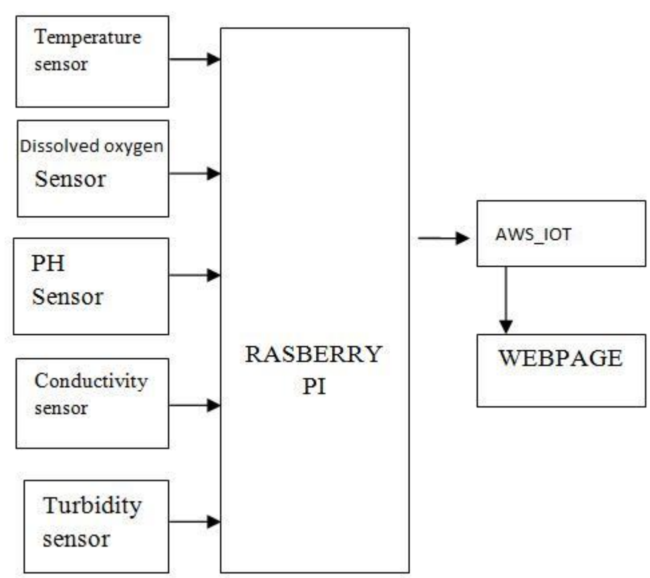

Fig.1.Water Quality Monitoring and Notification System

A. Discussion

Fish do not like any kind of changes in their environment. Any changes add stress to the fish and the larger and faster the changes, the greater the stress. So the maintenance of all the factors becomes very essential for getting maximum yield in a fish pond. Good water quality is characterized by adequate oxygen, proper temperature, transparency, limited levels of metabolites and other environmental factors affecting fish culture. The initial studies of water quality of a fish pond in India were probably conducted by Sewell (1927) and Pruthi (1932). After that many workers have studied the physico-chemical condition of inland waters either in relation to fish mortality or as part of general hydrological survey (Alikunhi et al., 1952: Upadhyaya, 1964). The details of various pond ecosystems also have been studied by workers (Mumtazuddin et al., 1982: Delince, 1992: Garg and Bhatnagar, 1999: Bhatnagar, 2008). Bhatnagar and Singh (2010) studied the pond fish culture in relation to water quality in Haryana. However, the present chapter would provide the basic guidelines, parameter wise for the fish farmers in obtaining high fish yield in low input via maintaining water quality of their ponds.

Temperature is defined as the degree of hotness or coldness

In the body of a living organism either in water or on and (Lucinda and Martin, 1999). As fish is a cold blooded Animal, its body temperature changes according to that of Environment affecting its metabolism and physiology and ultimately.

Affecting the production. Higher temperature Increases the rate of bio-chemical activity of the micro biota, Plant respiratory rate, and so increase in oxygen demand. It further cause decreased solubility of oxygen and also increased level of ammonia in water. However, during under Extended ice cover, the gases like hydrogen sulphide, carbon Dioxide, methane, etc. can build up to dangerously high levels

affecting fish health.Desirable limits According to Delince (1992) 30-350C is tolerable to fish, Bhavnagar et al. (2004) suggested the levels of temperature as 28-320C good for tropical major carps; ¡120C lethal but good for cold water species; 25-300C ideal for Penaeous monodon culture; ¡ 200C sub lethal for growth and survival for fishes and ¿ 350C- lethal to maximum number of fish species and according to Santhosh and Singh (2007) suitable water temperature for carp culture is between 24 and 300C. Remedies

1. By water exchange, planting shady trees or making artificial shades during summer's thermal stratification can be prevented.
2. Mechanical aeration can prevent formation of ice build-up in large areas of the pond.

Turbidity

Ability of water to transmit the light that restricts light penetration and limit photosynthesis is termed as turbidity and is the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the

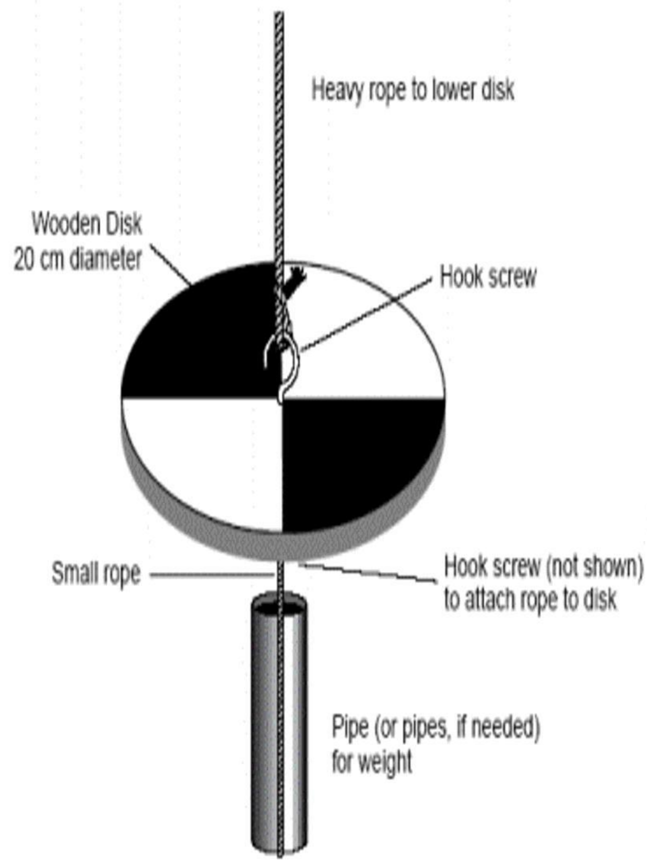

Fig. 2. turbidity disc

Decomposition of organic matter.

Desirable limits

Boyd and Lichtkoppler (1979) suggested that the clay turbidity in water to 30 cm or less may prevent development of plankton blooms, 30 to 60 cm and as below 30 cm - generally adequate for good fish production and there is an increase in the frequency of dissolved oxygen problems when values above 60 cm, as light penetrates to greater depths encourage underwater macrophyte growth, and so there is less plankton to serve as food for fish. According to Bhatnagar et al. (2004) turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture system and

¡ 12 cm causes stress. According to Santhosh and Singh (2007) the secchi disk (fig.1) transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture.

Remedies

Addition of more water or lime (CaO, alum Al2(SO4)314H2O at a rate of 20 mg L-1 and gypsum on the entire pond water at rate of 200 Kg/ 1000m3 of pond can reduce turbidity.

Dissolved Oxygen (DO)

Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms (Solis, 1988). The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones, due to low solubility of oxygen in water and solubility decreases with factors like-increase in temperature; increase in salinity; low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly (Bhatnagar and Garg, 2000).

Indication of low Dissolved oxygen

If fish comes to the surface of water (figure 2) and secchi Disk reading falls below 20 cm, fish swim sluggishly and are Weakened. Desirable limits According to Banerjea (1967) DO between 3.0-5.0 ppm in ponds is unproductive and for average or good production it should be above 5.0 ppm.

It may be incidentally mentioned

That very high concentration of DO leading to a state of super Saturation sometimes becomes lethal to fish fry during the Rearing of spawn in nursery ponds (Alikunhi et al., 1952) so for oxygen, the approximate saturation level at 50 F is 11.5 Mg L-1, at 70 F., 9 mg L-1, and at 90 F., 7.5 mg L-1. Tropical Fishes have more tolerance to low DO than temperate fishes. According to Bhatnagar and Singh (2010) and Bhatnagar et al. (2004) DO level ¿5ppm is essential to support good Fish production. Bhatnagar et al. (2004) also suggested that 1-3 ppm has sub lethal effect on growth and feed utilization; 0.3-0.8 ppm is lethal to fishes and ¿14 ppm is lethal to fish Fry, and gas bubble disease may occur. DO less than 1- Death of Fish, Less than 5 -Fish survive but grow slowly and will Be sluggish, 5 and above- Desirable. According to Santhosh And Singh (2007) Catfishes and other air breathing fishes can Survive in low oxygen concentration of 4 mg L-1. Ekubo and Abowei (2011) recommended that fish can die if exposed To less than 0.3 mg L-1 of DO for a long period of time, Minimum concentration of 1.0 mg L-1 DO is essential to Sustain fish for long period and 5.0 mg L-1 are adequate in Fishponds.

Remedies

(i) Avoid over application of fertilizers and organic manure to manage DO level (ii) Physical control aquatic plants and also management of phytoplankton biomass (iii) Recycling of water and use of aerators. (iv) Artificially or manually beating of water. (v)Avoid over stocking of fishes. (vi) Introduction of the hot water gradually with pipes to reduce if DO level is high.

pH

pH is measured mathematically by, the negative logarithm of hydrogen ions concentration. The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas (Boyd, 1979).

Desirable limits

water-quality ph

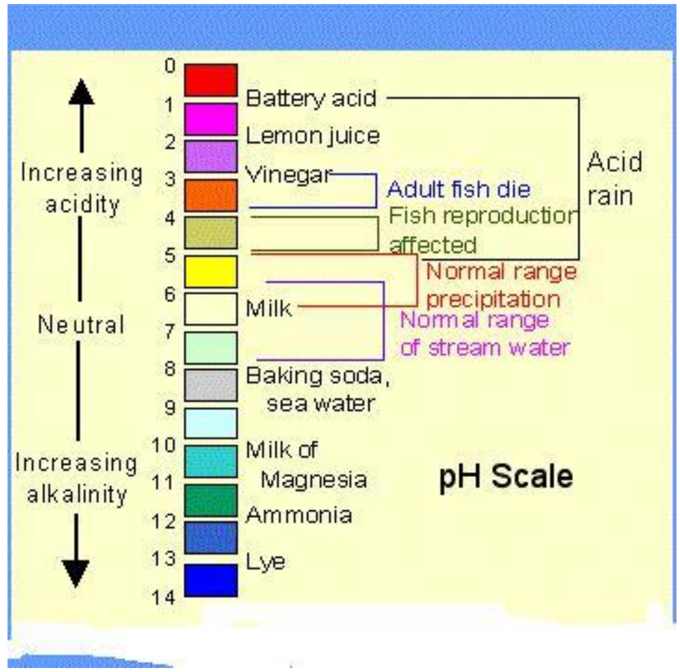

Fig. 3. water-quality ph

Fish have an average blood pH of 7.4, a little deviation from This value, generally between 7.0 to 8.5 is more optimum And conducive to fish life. PH between 7 to 8.5 is ideal for Biological productivity, fishes can become stressed in water With a ph ranging from 4.0 to 6.5 and 9.0 to 11.0 and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011). According previous statics the suitable pH range for fish culture is between 6.7 and 9.5 and deal pH level is between 7.5 And 8.5 and above and below this is stressful to the fishes. Ideally, an aquaculture pond should have a pH between 6.5 and 9 (Wurts and Durborow, 1992: Bhatnagar et al., 2004). Bhatnagar et al. (2004) also recommended that ¡4 or ¿10.5 is Lethal to fish/shellfish culture; 7.5-8.5 is highly congenial for P.monodon; 7.0-9.0 is acceptable limits; 9.0 -10.5 is sub lethal for fish culture.

Remedies

1. Add gypsum ($CaSO_4$) or organic matter (cowdung, poultry droppings etc.) and initial pre-treatment or curing of a new concrete pond to reduce pH levels. 2. Use of quicklime (CaO) to rectify low pH of aquatic body.

Conductivity

Conductivity is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water (Ogbeibu and Victor, 1995). Conductivity can be used as indicator of primary production (chemical richness) and thus fish production. Conductivity of water depends on its ionic concentration (Ca^{2+}, Mg^{2+}, HCO_3^-, CO_3^-, NO_3^- and PO_4^-), temperature and on variations of dissolved solids. Distilled water has a conductivity of about 1 mhos/cm and natural

Waters have conductivity of 20-1500 mhos/cm (Abowei, 2010). Conductivity of freshwater varies between 50 to 1500 Hs/cm (Boyd, 1979), but in some polluted waters it may reach 10,000 hs/cm and seawater has conductivity around 35,000 Hs/cm and above.

Desirable limits

As fish differ in their ability to maintain osmotic pressure, therefore the optimum conductivity for fish production differs from one species to another. Sikoki and Veen (2004) described a conductivity range of 3.8 -10 hs/cm as extremely poor in chemicals, Stone and Thomforde (2004) recommended the desirable range 100-2,000 mSiemens/cm and acceptable range 30-5,000 mSiemens/cm for pond fish culture. Salinity

Salinity is defined as the total concentration of electrically charged ions (cations Ca++, Mg++, K+, Na+ ; anions CO3-, HCO3-, SO4-, Cl- and other components such as NO3-, NH4+ and PO4). Salinity is a major driving factor that affects the density and growth of aquatic organisms population (Jamabo, 2008).

Desirable limits

Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in its bloodstream through the movement of salts and water across their gill membranes. According to Meck (1996) fresh and saltwater fish species generally show poor tolerance to large changes in water salinity. Often salinity limits vary species to species level. Garg and Bhatnagar (1996) have given desirable range 2 ppt for common carp; however, Bhatnagar et al. (2004) gave different ideal levels of salinity as 1020 ppt for P. monodon; 10-25 ppt for euryhaline species and 25-28 ppt for P. indicus. Barman et al. (2005) gave a level of 10 ppt suitable for Mugil cephalus and Garg et al. (2003) suggested 25 ppt for Chanos chanos (Forsskal).

Remedies

1. Salinity is increased or diluted by replenishment of water.
2. Aeration is essential to equalise the water salinity all over the water column.

II. CONCLUSION

How to detect pond water of poor quality

The following guidelines are given to a fish farmer to know when pond water is deteriorating in quality and therefore not suitable for fish growth.

1. Clear water indicates very low or absence of biological production- not fertile enough and fish will not grow well in it.
2. Muddy water (that is a lot of clay particles are present), fish can have their gills blocked by the soil particles and this can result in death - not good for fish culture.
3. Deep green water indicates over-production of planktons that serve as food for fish but occur as a result of application of more than enough fertilizers, manure or nutrient rich feeds to a pond.
4. When a fish pond gives an offensive odour, it indicates pollution of pond water. Sources of pollution include

water-quality parameters

Recommended Water Parameters for Successful Culture of P.monodon.

WATER PARAMETERS	OPTIMUM LEVEL	COMMENTS
pH	7.5 - 8.5	Daily fluctuation < 0.5
SALINITY	10 - 30 ppt	Daily fluctuation < 5 ppt
DISSOLVED OXYGEN	5 - 6 ppm	Not less than 4 ppm
ALKALINITY	80 – 120 ppm (as CaCO3)	Dependent on pH Fluctuation
SECCHI DISC	30 – 40 cm	-
H2S	< 0.03 ppm	More toxic at low pH
UNIONIZED AMMONIA	< 0.1 ppm	More toxic at high pH and Temperature
UNIONIZED NITRITE	< 0.5 ppm	More toxic at low pH

Fig. 4. Water-quality parameters

Application of excess food stuff to the pond, or inflow of water from polluted rivers. Pollution can also result from application of chemicals to arable crops around the pond site.

5. In an already stocked fishpond, if a farmer noticed the fish always struggling at the pond water surface to get oxygen, then there is low DO content in the water (fig. 2).

The optimum range of various water quality parameters are summarized in Table-1.

Table 1: Suggested water-quality criteria for pond water fishery for getting high yield via applying minimum input.

APPENDIX

APPENDIX A: water-quality ph

APPENDIX B: water-quality parameters

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EXPERIMENTAL RESULTS

The implementation of realization of "Wireless Remote Monitoring system using Raspberry Pi and AWS IOT technology" is done successfully as shown in Figs. The communication is properly done without any interference between different modules in the design. Design is done to assemble all the specifications and requirements.

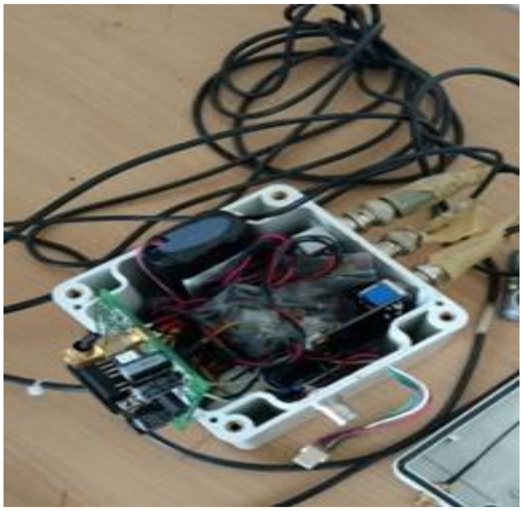

Fig (1) Assembling the Sensor with RPi

Fig (2) Sensor dipping into water

Table 1 Water quality parameters measured results

Date	Time/h	Temperature/ ^0C	Dissolved oxygen	turbidity	conductivity	PH
2017.08.15	11	20.8	13.25	8.37	1.09	8
2017.08.15	10	19.8	12.38	8.42	1.04	10
2017.08.15	9	19.2	13.25	8.45	1.01	10
2017.08.15	8	19.1	13.36	8.45	1.01	10
2017.08.15	17	18.6	7.25	21.62	0.58	7.21
2017.08.15	16	18.8	3.86	34.62	0.33	7.20
2017.08.15	15	18.9	4.02	34.62	0.91	4.91
2017.08.15	14	19.0	4.25	34.62	0.68	5.04
2017.08.15	17	17.0	12.25	5.29	0.42	7.25
2017.08.15	16	17.2	11.24	6.43	0.56	7.26
2017.08.15	15	17.4	11.45	6.43	0.59	7.22
2017.08.15	14	17.4	11.52	6.55	0.57	7.44

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