The design and software development of remote monitoring system for aerator

Zewen Zhang2,a, Wenwu Mao1,*, Cheng Li3, Dengkui Wang3, Yuanxiang Zhang1, Qian Liu4

1College of Engineering Science and Technology, Shanghai Ocean University, Shanghai, China
2College of Food Science and Technology, Shanghai Ocean University, Shanghai, China
3College of Fisheries and Life Science, Shanghai Ocean University, Shanghai, China
4College of Information Technology, Shanghai Ocean University, Shanghai, China

*Corresponding author e-mail: wenwumao@126.com, jiezhang@shou.edu.cn

Abstract: Aerator is an aquaculture device extensively applied. It is mainly used to adjust dissolved oxygen content in the aquaculture water so as to guarantee fishes in the water will not be die from oxygen deficit. However, at present, the aerator requires higher for experience and has intensive work strength of aquaculture workers. In order to improve the reasonability, accuracy and convenience of aerator, this paper designs remote monitoring system and develops software of aerator based on Java Web and PhoneGap, including overall design of remote monitoring system, Java Web application, PhoneGap mobile frame application, SQL Server database application. It realizes remote monitoring of aerator through PC or smart phones.

1. Introduction

Aerator is an aquaculture device extensively applied. It is mainly used to increase dissolved oxygen content in the aquaculture water so as to guarantee aquatic lives such as fishes in the water will not be die from oxygen deficit. Meanwhile, it could restrict growth of anaerobic bacteria in water, and prevent from water deterioration which may threaten living environment of aquatic lives. However, at present, the aerator is opened and closed depending on experience of aquaculture workers. Such experience is mainly shown in judgment of oxygen content in water, control of start/close time of aerator, and skillfulness of species farmed. It requires highly for technical level, work strength and work attitude of aquaculture workers, and has large blindness and high risks. Therefore, it is of great economic and social significance to develop aerator remote monitoring system.

2. Impact of water dissolved oxygen content on aquatic lives

The dissolved oxygen content in water is an important factor affecting growth and development of fish and other aquatic lives. The dissolved oxygen content for farming of fish, shrimps and crabs shall be kept at 5–8mg/L, at least above 4mg/L. When the oxygen content in water is unable to meet the demands of respiration, fish will strengthen and speed up their reparation and always gasp for air; shrimps and crabs will suffer difficulty in shell moulting. If the dissolved oxygen content in water is zero and not supplemented in time, the anaerobic bacteria in water will be rapidly bred, urging anaerobic digestion and generating water pollution by harmful gas such as methane, hydrogen sulfide...
and ammonia. When the dissolved content in water is excessively high, the fish fry may suffer bubble disease. Table 1 shows scope of application of dissolved oxygen for common fish, shrimps and crabs, and content index of gasping for air and death by suffocation. [1][2]

Table 1. Dissolved oxygen required by fish, shrimps and crabs

| Specie                          | Applicable scope mg/L | Gaspig for air, mg/L | Death by suffocation, mg/L |
|---------------------------------|------------------------|----------------------|---------------------------|
| Crucian                         | 4~5                    | 1.0                  | 0.1                       |
| Hypophthalmichthys molitrix     | 5.5~8                  | 1.75                 | 0.6                       |
| Mandarin fish                   | 6~8                    | 1.5                  | 0.8                       |
| Carp                            | 5~8                    | 1.5                  | 0.3                       |
| Aristichthys nobilis            | 4~8                    | 1.55                 | 0.4                       |
| Tilapia mossambica              | 6~9                    | 1.5                  | 0.2                       |
| Ctenopharyngodon idella         | 5~8                    | 1.6                  | 0.5                       |
| Silurus meridionalis fish       | 5~8                    | 1.4                  | 0.7                       |
| Leiocassislongirostris Gunther  | 5~7                    | 2.8                  | 1.5                       |
| Megalobrama amblycephala        | 5.5~8                  | 1.7                  | 0.6                       |
| Japanese eel                    | 4~9                    | 1.4                  | 0.6                       |
| Fenneropenaeus chinensis        | 6~8                    | 1.4                  | 0.4                       |
| Penaeus monodon                 | 5~8                    | 1.2                  | 0.3                       |
| Macrobrachium rosenbergii       | 7~9                    | 1.5                  | 0.5                       |
| River crab                      | >5                     | 2.5                  | 1.5                       |

Different species of aquatic lives have various dissolved oxygen demands, and the same specie also has different dissolved oxygen demand in different growing stages. Studies on Larimichthys Crocea [3], Pagrus Major [4], Metapenaeus ensis DeHaan [5], Oratosquilla Oratoria [6], Cherax Quadricarinatus Von Martens [7], Scylla paramamosian [8] and Portunus trituberculatus [9] show: With growth of lives, the proportion of brain and internal organs to overall body is reducing, while of bones and muscles is increasing. The bones and muscles have smaller oxygen consumption than important tissues and organs which maintain the life. Therefore, the smaller the body is, the smaller
the overall oxygen consumption will be and the higher the oxygen consumption rate will be. Table 2 shows oxygen consumption volume, oxygen consumption rate and average body mass of Portunus trituberculatus in different development stages. [9]

**Table 2. Oxygen consumption volume, oxygen consumption rate and average body mass of Portunus trituberculatus in different development stages**

| Development stage     | Oxygen consumption volume/ (mg·crab⁻¹·h⁻¹) | Oxygen consumption rate/ (mg·g⁻¹·h⁻¹) | Average body mass/g |
|-----------------------|-------------------------------------------|--------------------------------------|---------------------|
| Stage I zoea          | 0.0451±0.01                              | 312.6081±1.46                        | 0.00014±0.00001     |
| Stage II zoea         | 0.1066±0.01                              | 213.4287±0.59                        | 0.00051±0.00002     |
| Stage III zoea        | 0.1668±0.02                              | 203.1257±1.46                        | 0.00082±0.00013     |
| Stage IV zoea         | 0.1135±0.02                              | 143.3165±1.43                        | 0.00079±0.00013     |
| Megalopa              | 0.2008±0.04                              | 87.5141±0.66                         | 0.00229±0.00045     |
| Stage I juvenile crab | 0.8997±0.27                              | 58.6251±1.57                         | 0.01532±0.00451     |
| Stage II juvenile crab| 1.3169±0.50                              | 42.6806±1.64                         | 0.03114±0.01211     |
| Stage III juvenile crab| 1.1350±0.11                           | 14.4369±1.40                         | 0.07958±0.01503     |
| Stage IV juvenile crab| 1.2874±0.24                              | 6.8389±1.69                          | 0.18994±0.01039     |

3. Overall solution of the monitoring system

Overall solution of the aerator remote monitoring system can be seen in Fig. 1, mainly including: monitoring facilities, dissolved oxygen sensor, microcontroller, communication module, database and client. Firstly, the monitoring facility is used to monitor culture environment information, and dissolved oxygen sensor is used to detect dissolved oxygen content in water; the monitoring data is sent to the database after being processed by the microcontroller. Later, the value of dissolved oxygen content is compared with the system setting value. If the value is within the normal scope, the dissolved oxygen data is stored to the database; if the value is beyond the normal scope of the setting value, the information will be transmitted to the monitoring center and user’s mobile for warning through communication module, so as to remind the user to start/close aerator.

![Fig.1 Overall solution of the aerator remote monitoring system](image-url)
4. Dissolved oxygen monitoring process

The dissolved oxygen monitoring process can be seen in Fig. 2. The dissolved oxygen sensor tests the content every 15 min; when the dissolved oxygen content is lower than the minimum value of the suitable scope, the sensor will test dissolved oxygen data five times every 2 min; if the mean value of five tests is confirmed lower than the suitable minimum value, the aerator will be started to adjust dissolved oxygen content to normal level according to species of aquaculture, culture density, development stage and weather conditions based on the set mode.

Fig. 2. Process flow chart of dissolved oxygen monitoring feedback adjustment
5. Design and development of monitoring system software

The aerator remote monitoring system software is comprised of PC monitoring center and mobile client, and is designed and developed based on Java Web, Phone Gap technology and SQL Servers database. Main contents of system design and development are application of database connecting components such as JavaBean, JDBC and Hibernate, design of database sheets, confirmation of related attributes of database sheets, realization of core code and coding, data processing of dynamic pages and Bootstrap framework usage. Ajax technology is used for data collection and transmission as well as development of single-chip microcomputer control program.

5.1 Fish pond management

The fish pond management is divided to three parts: adding fish pond, selecting species and emptying the fish pond. The fish pond sheet of database may be added to add fish pond, and the name of new fish pond will be set automatically to make preparation for adding species; when selecting species, the information of species selected should be sent to corresponding action document. The action document will input species information to corresponding attribute of database fish pond, and set the pond status to “in use”. To empty the fish pond, the id of fish pond selected could be sent to corresponding action document, empty the database information of the pond, and set pond status to “not enabled”. The management interface of fish pond information can be seen in Fig.3, and species selection interface can be seen in Fig.4.

![Fish pond information management interface](image1)

**Fig.3** Fish pond information management interface

![Species information list](image2)

**Fig 4.** Species selection interface

5.2 Aerator management

The aerator management contains adding aerator and aerator control. For the former, the action document could be used to inquire the aerators in current fish pond in database, automatically name the newly added aerators and set the aerator “closed”. For the latter, the startup requirements may be used to judge whether it is necessary to open or close the aerator; when operation is required, the aerator may be controlled by its switch. The management interface of the aerator can be seen in Fig.5.

![Aerator management interface](image3)
6. Conclusion
The aerator is used to remotely control the system. Even if the aquaculture workers are absent, they could know dissolved oxygen content of each pond through computer and mobile, and remotely control the aerator and adjust dissolved content to normal level according to culture species, density, development stages and weather conditions based on the set mode. In this way, the work strength of aquaculture workers is eased greatly, and reasonability and precision of aerator is improved to a high level.

7. Acknowledgement
This project is subsidized by the open fund of Key laboratory of Fishery Equipment and Engineering, Ministry of Agriculture of the People’s Republic of China.

References
[1] Song Ping. Significance of Dissolved Oxygen in Aquaculture (I) [J]. Scientific Fish Farming, 2013,1.
[2] Liu Huan. Functions of Water Analysis in Pond Aquaculture [J]. Current Fisheries, 2019, 9: 83-89
[3] Su Yuezhong, You Lan. Preliminary Research on Asphyxiati on Point and Oxygen Consumption of Juvenile and Young Larimichthys Crocea [J]. Journal of Fujian Fisheries, 1995 (4): 20-24.
[4] Dong Cunyou, Zhang Jinrong. Preliminary Measurement of Asphyxiati on Point and Oxygen Consumption of Pagrus Major [J]. Journal of Fisheries of China, 1992,16 (1): 75-78.
[5] Jiang Jingnan. Study on Oxygen Consumption, Respiratory Quotient and Asphyxiati on Point of Metapenaeus ensis DeHaa n [J]. Martine Fisheries, 1993 (2): 63-66.
[6] Mei Wenxiang, Wang Chunlin. Preliminary Research on Oxygen Consumption Volume, Rate and Asphyxiati on Point of Oratosquilla Oratoria [J]. Journal of Zhejiang College of Fisheries, 1993,12 (4): 249-255.
[7] Chen Xiaoxuan, Wu Zhixin, Wu Qing, et al. Study on Oxygen Consumption and Asphyxiati on Point of Cherax Quadricarinatus Von Martens [J]. Journal of Huazhong Agricultural University, 1999, 15 (3): 270-279.
[8] Wang Jiangang, Tang Baojun, Qiao Zhengu, et al. Preliminary study on the oxygen consumption rate and suffocation point of juvenile crab Scylla paramamosian [J]. Martine Fisheries, 2010, 32 (3): 345-350.
[9] Xu Jinrong, Wang Chunlin, Mu Changkao, Zhang Linlin. Relationship between oxygen consumption and oxygen consumption rate and the body mass of Portunus trituberculatus at its early development stages [J] Journal of Marine Sciences, 2012, 30 (1): 102-106.