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# Automated dissolved oxygen sensing and aerator activation in aquaculture

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## Proper installation is paramount

Aquaculturists live with the nagging fear that their ponds will “crash” from low dissolved oxygen (DO), and result in a major financial loss from the death of stocked animals. The fear becomes more acute, if not pathogenic, as stocking densities and daily feed inputs increase. If a farm is large, a nighttime person is usually hired to monitor DO concentrations and activate aeration devices, if necessary.

Some farmers estimate when aeration will be needed and activate aerators with timers. Others do not want to be bothered with checking DO during the night and activate aerators early in the evenings whether necessary or not. All of these methods have their advantages, but they all depend on human intervention, and they are not fool proof.

For a number of years, devices have been available to automatically determine dissolved oxygen concentration and activate aeration devices. Recently these devices have been systematized for use with the desktop computer and made commercially available to producers. At a recent trade show for catfish producers I counted five different systems for sale, and I know of at least one other. In contrast, in 1988 when I first began working with automated systems by piecing together electronic components, to my knowledge there were no commercially available automated systems. During the last four years I have worked with two very different commercial systems in brackish water aquaculture, and have formed opinions on what features a system should include to be a practical tool for the producer.

Heavy fouling of dissolved oxygen probe with barnacles and other organisms as compared to clean probe at left.

## The bottom line

With the current technology, computerized pond monitoring and decision making systems should be easy to build. In fact, the pieces of the system are available, but the difficulty lies in assembling these pieces into a tough, reliable, pond-side unit that can be understood and maintained by producers, and is financially feasible. Producers require absolute reliability in order to release care of a pond to an instrument. The bottom line for most producers is whether the system will increase profits or, at the least, decrease the risk of animal mortality.


(https://aceaquatec.com/aquaculture-products/grow/a-biomass)

## Automated sensors and energy cost

Our studies have indicated that automated systems can decrease the energy cost of aeration, but this factor alone is unlikely to pay for a system over a five-year period. Most systems will cost between $2,000 and $3,500 U.S. per 5-ha pond. If one oxygen-related pond kill can be avoided in a pond once every five years by using the automated system, then the cost of the system is more than justified. Because a producer may not know if a pond was saved because of automated DO monitoring, automated systems may be viewed as a form of insurance against crop loss. Insurance becomes more appealing as stocking densities and feeding rates increase. Small- to medium-size farmers may opt for the automated systems, not because of the insurance factor, but to avoid hiring additional labor and thereby justify its cost.

Control panels with automated system for controlling aerators based on dissolved oxygen levels.

# Automated DO-sensing

Most automated systems consist of a pond-side computer that controls an oxygen sensor in the pond, makes a decision to activate or deactivate an aerator based on the DO concentration, and communicates with a desktop computer at the manager's home or office. The communication link between pond-side and desktop computers can be by wire, or if long distance, by radio or satellite. Software is usually provided with the system to allow the producer to communicate with each of his sensors, format data output, and view it graphically in real time. The user-friendliness of the software is an important feature of automated systems. The software must function well with Windows or Macintosh operating systems, and be easy to use by personnel without much computer training. The data should be archived in a form that is easily accessible for analyses at a later date.

## *Calibration*

An inherent design dilemma in all automated systems is how to calibrate the DO sensor to ensure accurate determinations. Calibrations must be done in humid air and take into account air temperature and atmospheric pressure. One system I work with has solved this problem by locating the oxygen sensor in a chamber that can be pumped free of water once a day to calibrate. The other system I use requires that operators retrieve the sensor from the pond and calibrate it manually. The sensor only requires calibration monthly; otherwise, the procedure would become tedious and impractical. Other systems automatically remove the sensor from the water for calibration. Any system that requires moving parts (pumps, mechanical arms, etc.) to accomplish the job ultimately creates other problems because moving parts require maintenance, particularly in saltwater environments.

## *Maintenance*

Another important design consideration for obtaining accurate DO determinations is the maintenance of a clean DO sensor membrane. Sensor membranes become fouled very quickly with organic matter, particularly in a marine environment. One of the systems we use incorporates an innovative design for leaking chlorine to the sensor chamber to oxidize organic matter. Of course, a concentrated solution of chlorine may also attack other materials on the sensor, and the chlorine chamber must be refilled periodically. The other system we use incorporates a sensor that can be fitted with a brush that mechanically sweeps across the membrane every couple of seconds. The sweeping motion of the brush also replenishes water near the sensor membrane for accurate DO measurements. The downside of the brush system is that the brush mechanism itself requires cleaning to maintain good freedom of movement, and the internal coil core and spring of the mechanism require maintenance.

## *Equipment failure warning*

No automated system is worth buying if it does not do self-checks and warn the producer of equipment failure. Warnings can be flashing lights, buzzers, computer messages, and telephone calls. Sensors must also be wired in line with aeration devices to monitor their operational status. We have lost the crops in a number of ponds on our experimental facility because of aerator malfunction or electrical supply problems. The automated sensing equipment was working fine, but we had not invested in an optional system to warn us that the aerators had failed. Warning systems should not be optional. There is no use in having automated DO sensing and aerator activation systems if a worker has to be up all night to verify that aerators are functioning.

## *Mechanical parts*

The electronic components and oxygen sensors of the automated systems we use have been reliable, but we have had many problems with the mechanical portions of the systems. Sensors cannot be put in place and forgotten for weeks at a time, as advertised by some companies. In aquatic environments, particularly those with salty water, any moving part is subject to corrosion. Water leaking past a pump seal can oxidize the motor. Parts quickly become encrusted with algae, barnacles and a host of other organisms that can hinder movement.

Unfortunately, the mechanical pieces are hidden from view so troubleshooting is often by indirect observation and trial and error. Unless the producers are particularly attentive, they may not even know that their instruments are malfunctioning until a problem becomes acute. The malfunction usually is from the discalibration of a sensor because of an improperly functioning pump or temperature sensor, or a dirty DO sensor membrane. Successful systems will be designed to minimize moving parts in order to reduce equipment failure and maintenance. Equipment will be simple enough for producers to troubleshoot most problems easily and perform most maintenance chores themselves.

## *Service and support*

Good company service is essential to promoting automated systems. One of the systems I use arrived in about eight different boxes over a 1-month period and I installed it. The other system arrived as a functional unit and was installed by the sales company. Successful systems in the future will be sold as preassembled, functional units installed by company technicians. In the early days of personal computers, the consumer had to know enough about computing equipment to choose and assemble the different components of a system. Now personal computers are sold as complete systems to the general public, who only has to choose how much to pay.

Similarly, most producers do not have the expertise or time to choose, assemble and install different components of an electronic system. They want something that can be plugged in and used. Company technicians should install automated systems or there will be no end of problems, ranging from equipment burnout from lightening strikes to malfunctioning warning systems. Following installation, successful companies will provide a high quality maintenance service to producers, because problems will arise that the producer is unable to fix. When an automated system functions well, producers will wonder how they lived without it; when the system malfunctions repeatedly, they will know why they did not install one sooner!

# Conclusion

In summary, I think automated oxygen sensing and aerator activation devices will be more common than not on farms within the next 10 years. A bewildering variety of system designs are rapidly becoming available to the producer. Prices are important, but more importantly, prevalent equipment in the future will be easy to use and troubleshoot, require minimal maintenance and be provided with excellent technical support.

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