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Innovative technologies for monitoring and detection of diseases in aquatic animals

Ravikumar M. Chovatia[a], Parmar Bindiya Kirtikumar[a], Chandana Dinakaran[b], Samad Sheikh[b] and Arpit Acharya[b,*]
[a]Kerala University of Fisheries and Ocean Studies, Kochi – 682506
[b]ICAR- Central Institute of Fisheries Education, Mumbai, India
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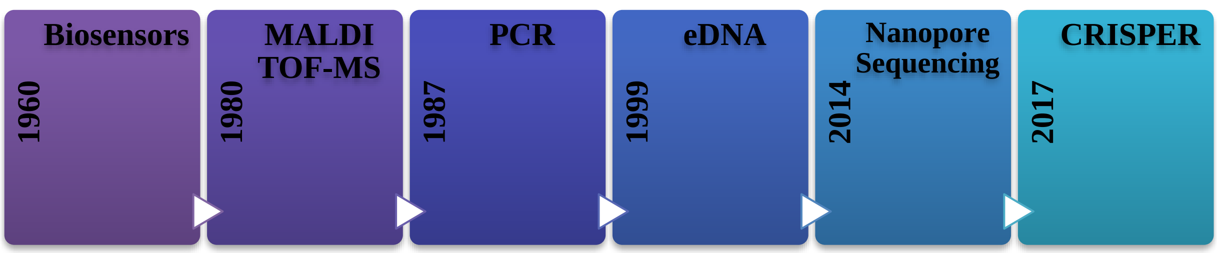
Introduction

The aquaculture sector has seen a significant jump in the production since last decade. The intensive farming practices has led to increased profitability to the farmers. The adaptation of best management practices (BMP) by the fisher's community has led to the development of skilled and precise farming techniques. The use of multiple candidate species in farming and diversification in the culture practices has given a greater impact in the global aquaculture status. According to the "State of World Fisheries and Aquaculture 2022," aquaculture production for human consumption was 157 million tons, and by 2030, it is expected to rise by 15% to fulfil the growing need of the growing population. To protect natural resources for future generations, this increasing output must be more ecologically sustainable. Aquaculture production is impacted by a number of factors, including pollution, climate change, agricultural methods, legal concerns, water quality, and infections. Nonetheless, increased productivity and sustainability have resulted from the technological advancements in aquaculture. Aquaculture is utilizing advanced technology in several areas, such as marketing, genetics, nutrition and health management.

Frequent variations in water quality, temperature, sunshine, dissolved oxygen, pH levels, and plankton density are common in aquatic environments. Farmers utilize sensors to continuously check the parameters of the water quality, and they may use mobile phones to identify any variation from ideal circumstances. Aquatic animals may be more susceptible to illness as a result of alterations in water quality factors. The worldwide aquaculture business suffers billion-dollar losses each year as a result of fish illnesses. While developing methods to improve disease resistance through vaccine development, researchers are actively looking for techniques to identify and cure fish infections in their early stages. Finding the microorganism causing the issue is referred to as disease diagnostics. In aquaculture, there are two categories for disease diagnostics.

Presumptive diagnosis includes visual observation of the animal's symptoms using microscopy, drones and machine learning. Confirmatory diagnosis involves finding the cause with near-perfect accuracy using biochemical testing, serology and molecular techniques. Identifying pathogens plays an important role in rapidly implementing containment strategies. Surveillance involves a systematic approach to collect data on the prevalence of important diseases and pathogens, with the aim of producing informative reports on the disease situation in a particular area. Monitoring focuses on general observation, assessment and collection of data across an area with no particular purpose. Researchers face the challenge of identifying and monitoring novel pathogens and strain that affect different aquatic species. However, new pathogens can also be characterised using nanopore sequencing and other next-gen sequencing technologies.

The methods used today for diagnosing illnesses in aquaculture include visual inspection, biochemical analysis, cell culture, and molecular approaches. These methods can take days for bacterial diseases and months for viral infections, which can result in large losses. In order to identify infections quickly and precisely and stop more losses, new diagnostic technologies are required. Even in isolated locations without access to lab facilities, portable sequencing devices have the ability to sequence DNA or RNA in real time, enabling the identification of disorders within hours. Newly developed methods for the quick and accurate diagnosis of fish infections include microfluidic chips and CRISPR-based diagnostics. These techniques allow for the identification of many pathogens with a single test, saving time and effort during the diagnosis process. Since serology approaches for illness were first created, several diagnostic instruments have been developed.



Early diagnosis and monitoring methods

1. Sensors

Aquaculture growers have the highest priority when it comes to water quality.

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Temperature, salinity, light, nitrogen, ammonia, pH, dissolved oxygen, and nitrogen are important water quality characteristics in aquaculture. These factors are essential in affecting the general health, behaviour and productivity of fish. Aside from infections and hosts, environmental variables like aberrant water quality are part of the trio that can lead to illness in aquatic organisms. Water quality testing and monitoring are typically carried out in labs following sample collection via the titration technique. On the other hand, time and effort may be saved by using portable and on-farm sensors that can assess water quality in real time thanks to improved technology.

2. Drones

In both onshore and offshore aquaculture management techniques, farm monitoring is essential. Monitoring larger aquaculture farms may be expensive and labour-intensive. Aquaculture farm monitoring has made considerable use of remotely operated vehicles (ROVs). In order to identify illnesses and parasites, these technologies combine machine learning (ML) with artificial intelligence (AI). By interpreting exterior symptoms, image processing technologies allow for the real-time diagnosis of pathogens and time savings. Three different kinds of unmanned vehicle systems are used in aquaculture: autonomous underwater vehicles (AUVs), unmanned aerial vehicles (UAVs), and unmanned surface vehicles (USVs). Algal blooms, fish farms, and water quality are among things that UAVs are employed to monitor. UAVs with sensors are able to keep an eye on fish anomalies, equipment performance, feed, and ambient conditions as well as suspicious activities.

3. Artificial intelligence (AI) and machine learning (ML)

In order to train the model to carry out the decision-making process, AI and ML employ the learning process. Various machine learning methods may be applied in aquaculture to analyze the photos without requiring human interpretation. Through a variety of data transmission methods, such as cable connections, wireless technologies, mobile internet, and data storage options, information obtained from people, drones, and sensors may be easily channelled into ML and AI systems. however, is that there aren't enough distinct photographs of the illness to train the model with. It might be challenging to distinguish between various diseases since their symptoms can often be identical. Furthermore, it might be difficult to maintain picture databases for every aquatic species, and occasionally system failures can result in false positives.

Confirmatory diagnostic method

1. Nanopore sequencing

An important diagnostic technique for better understanding the evolution and detection of infections is next-generation sequencing (NGS) technology. It has been effectively used to diagnose illnesses in people, animals, and plants. However, there are a number of drawbacks to this technique, including its dependency on expensive machinery, lengthier turnaround times, and greater expenses. Aquaculture can benefit from the potential of nanopore sequencing to sequence the genomes of different fish species and aquaculture-affecting diseases, including new ones. Without sending the samples to a lab, it may quickly identify infections. Planning and managing viral infections in a timely manner will help avert future outbreaks by identifying them quickly and accurately. Moreover, microbiome analysis using nanopore sequencing is used to learn more about the health of fish. With the use of this tool, fish infections could be immediately identified in remote areas and outbreaks can be immediately prevented to stop future spread and financial losses.

2. Biosensors

In order to detect target substances, biosensors use biological components like enzymes and antibodies, which alter parameters like current, resistance, or heat. These biocatalysts are helpful for identification and measurement because they have the ability to produce or consume chemicals when they interact with the target substance. When an organism is present, a biosensor can quickly identify minute changes in signal. The biological reaction's efficiency can be increased by a variety of receptor-based biosensors, such as enzymes, antibodies, aptamers, whole cells, and nanoparticle biosensors. Biosensors are used in the food industry for disease diagnostics as well as the detection of environmental contaminants and contamination. Biosensors are employed in aquaculture for the purpose of diagnosing diseases and identifying cyanobacterial pollutants in water. Farmers might be given more authority by biosensors since they can quickly identify infections using simple test strips. Remote and underdeveloped regions of the world may benefit from this accessibility.

3. Clustered regularly interspaced short palindromic repeats-based (CRISPR) diagnostic method

Deployable technologies are required for quick diagnoses. CRISPR is a newly developed technology with a wide range of uses and quick illness diagnosis. Based on similarities, this approach uses related endonucleases to identify and remove alien sequences. Numerous CRISPR-endonucleases that target foreign DNA or RNA bases in the CRISPR RNA sequence have been found from bacteria and archaea. If necessary, the RNA can be changed to remove the target. In both agriculture and the diagnosis of human diseases, CRISPR is widely utilized. Because of their special qualities, CRISPR-Cas systems like as cas12a (Cpf1) and cas13 are widely employed in aquaculture for diagnostic purposes. Diagnostics based on CRISPR-Cas are becoming more popular because to their great sensitivity in identifying low copy numbers and ease of use. The goal of CRISPR diagnostics is to be field-deployable in aquaculture; however,

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particularity regarding sample preparation and temperature requirements impedes development.

4. Matrix-assisted laser desorption ionisation time of flight mass spectrometry (MALDI-TOF MS)

Mass spectrometry is used in the MALDI-TOF MS approach to diagnosis microorganisms. This technique has the potential to be used in aquaculture diagnostics since it is quick and affordable. Target samples are combined with a matrix and run through high voltage in MALDI-TOF mass spectrometry to separate the ions according to their mass-to-charge ratio. A time-of-flight (TOF) detector is then used to detect the separated ions. Using a database comparison, peptide mass fingerprinting (PMF) is used to determine the mass of an unknown protein. For clinical bacteriology, MALDI-TOF MS is utilized to identify various strains of bacteria and identify those that are resistant to antibiotics. Nonetheless, a significant constraint of this technique is its inability to accurately identify fungal and viral species. Furthermore, extensive databases for aquatic pathogens are necessary for reliable identification because they constitute the foundation of established pathogen identification databases. This increases the difficulty of implementing this technique for the detection of aquatic pathogens. Farmers in remote places with low availability to testing facilities are unable to apply this approach since it is not directly applicable to tissue samples and can only be used for laboratory-based diagnosis.

5. Environmental DNA/RNA (eDNA/eRNA)

New methods for finding DNA or RNA in environmental materials including soil, water, and air are called eDNA and eRNA. This technique collects nucleic acids that organisms—such as mucus, cysts, and spores—release into the environment. These genetic materials are collected via filters, and their existence is subsequently ascertained by purification. eDNA is frequently used in fisheries to identify various fish species in bodies of water without endangering the animal. Additionally, eDNA has demonstrated promise as a technique for aquatic pathogen surveillance. Numerous benefits come with eDNA and eRNA-based diagnostics, such as non-lethal sampling, no handling stress, cost- and time-effectiveness, and the capacity to identify various infections and their hosts from a single sample. The breakdown of nucleic acids, where DNA is more stable and simpler to detect than RNA, is the method's drawback. Furthermore, because infections are small and go through several life phases in water, it might be difficult to immediately identify them. Furthermore, therapeutic choices may be limited if clinical indications of the disease are not visible until late in the infection process. However, by overcoming these obstacles, eDNA approaches may improve aquaculture animal health monitoring systems.

Conclusion

Rising technologies including genetic engineering, digital aquaculture, fish meal substitutes, vaccinations, drones, artificial intelligence, and genetic engineering are changing the aquaculture business and making output more viable and sustainable. Since current techniques for detecting aquatic diseases are not able to identify pathogens quickly, they must be changed. Adoption of modern technologies is required since farm monitoring devices are expensive and labour-intensive. Small farmers find it difficult to reap the benefits of sophisticated technology because of high expenses, complex infrastructure, and restricted internet access in developing nations. Encouraging collaborations for the purpose of transferring technology and offering necessary instruction will ensure that these technologies are widely accessible. This will guarantee that these techniques are accessible in various nations, assisting in addressing concerns related to food security. A vital component of sustainable aquaculture production is early disease detection and prevention through efficient farm monitoring techniques. The development of the aquaculture sector depends heavily on technical research and innovation.

Reference

Bohara, K., Joshi, P., Acharya, K.P. and Ramena, G., 2023. Emerging technologies revolutionising disease diagnosis and monitoring in aquatic animal health. *Reviews in Aquaculture*.

FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en