feasibility of genetic improvement (Nguyen, 2024). In addition, emerging technologies such as RNA interference and CRISPR/Cas provide new tools for understanding disease resistance mechanisms and enabling precise genetic improvement. However, their practical application must consider ecological safety, regulatory frameworks, and cost factors (Wikumpriya et al., 2023). Overall, immunoregulation and genetic breeding are driving disease control strategies toward a host-centered approach focused on enhancing resistance.

6 Typical Prevention and Control Models and Practical Applications

6.1 Green ecological farming model

Eco-friendly shrimp aquaculture models achieve disease control by stabilizing pond ecosystems, reducing pathogen pressure, and minimizing chemical inputs. Integrated multi-trophic aquaculture (IMTA) and polyculture systems combine shrimp with fish, shellfish, and/or seaweeds, enabling nutrient recycling, improving water quality, and reducing the accumulation of opportunistic pathogens, thereby enhancing system stability (Arriesgado et al., 2025; Uddin et al., 2025). Studies have shown that IMTA systems in China exhibit diverse combinations, such as shrimp–crab, fish, sea cucumber, jellyfish, and shellfish, which can be optimized according to local ecological conditions. These systems not only improve resource utilization efficiency and reduce waste discharge but also significantly enhance economic returns compared to monoculture systems, while lowering disease risks and environmental pressure (Uddin et al., 2025). Furthermore, IMTA effectively removes excess nutrients, balances nutrient budgets, and reduces carbon emissions, making it an important approach for achieving both environmental and economic sustainability (Uddin et al., 2025).

Polyculture systems also serve as effective ecological disease control strategies. For example, a fish–shrimp co-culture model developed in China introduces specific fish species that actively consume dead or moribund shrimp, thereby interrupting the transmission of white spot syndrome virus (WSSV) within ponds. This approach does not require complex biosecurity infrastructure, is easy to implement, and is suitable for small- and medium-scale farmers. It has been widely adopted in China, effectively reducing WSS-related losses while increasing overall production. In addition, green water systems, biofloc technology, and the application of probiotics and prebiotics are considered effective alternatives for controlling bacterial diseases such as vibriosis. These approaches not only improve water quality but also promote growth, enhance stress resistance and disease resistance, and reduce environmental pollution (Noman et al., 2024; Arriesgado et al., 2025; Kumar et al., 2025).

6.2 Industrialized and recirculating aquaculture systems (RAS)

At the other end of the intensification spectrum, industrialized aquaculture and recirculating aquaculture systems (RAS) achieve disease control through enhanced biosecurity and environmental regulation. The future of sustainable shrimp farming lies in the development of efficient, biosecure systems based on SPF seedstock and genetically improved strains, combined with strict pathogen monitoring and quarantine measures throughout the production cycle. RAS and inland closed systems reduce reliance on open water sources and minimize contact with wild hosts. At the same time, indoor environmental control stabilizes key parameters such as temperature and salinity, thereby reducing pathogen exposure and disease risks associated with climate variability (Kumar et al., 2025). Although RAS offers advantages such as water conservation, high productivity, and reduced ecological impacts (e.g., habitat destruction, eutrophication, and escape events), its high energy consumption and capital costs limit its widespread adoption, particularly in developing countries.

Technological innovations are improving the sustainability and disease resistance of intensive aquaculture systems. For example, a high-density, low-salinity culture system for Litopenaeus vannamei integrating zero water discharge (ZWD) and RAS has demonstrated the ability to maintain good water quality at stocking densities up to 1000 individuals/m^3, with optimal survival and feed conversion efficiency achieved at 500 individuals/m^3, indicating strong potential for urbanized inland aquaculture. Membrane-based RAS (MRAS), incorporating microfiltration, ultrafiltration, and membrane bioreactors, can effectively remove suspended solids, toxic substances, pathogens, and excess nutrients, thereby improving water reuse efficiency and reducing environmental impacts. However, membrane fouling, energy consumption, and operational costs remain key challenges (Widiasa