IMTA offers significant advantages, including enhanced biodiversity and improved economic resilience through crop diversification. By recycling nutrients and reducing reliance on external inputs, this model aligns with "Blue Transformation" programs, integrating seaweed and bivalve farming with finfish cages (FAO, 2022b). Globally, aquaculture has grown at an average annual rate of 5.3% from 2001 to 2018, with IMTA gaining recognition for its role in enhancing food security (Barange et al., 2014). Despite its promise, the approach requires optimized system design to manage disease risks and ensure species compatibility. As seafood demand rises, IMTA provides a framework for climate-resilient practices by utilizing climate-tolerant native species and promoting water conservation (Goh et al., 2023).

Effective waste management in IMTA mitigates the negative impacts of intensification-such as soil and water degradation, fish stress, and reduced profitability (Asgard et al., 1998). By operating across different trophic levels, these systems function as complementary ecosystems where by-products are converted into fertilizer and energy for other crops (Jana et al., 2000). Utilizing acclimatized native species further ensures efficient bio-mitigation and sustained biomass growth. Ultimately, diversifying the production system keeps water quality parameters within balanced levels, achieving long-term sustainability in global food security (Kibria and Haque, 2018).

11 Biofloc Technology

Biofloc Technology (BFT) in aquaculture and the animal food industry represents a shift toward increasing biomass by maintaining a higher carbon-to-nitrogen (C:N) ratio. This ratio is essential to stimulate the establishment of a microbial community, primarily consisting of heterotrophic bacteria, which aggregate into significant clusters or "flocs" (Emerenciano et al., 2013). This technology has gained global popularity in countries such as South Korea, Brazil, China, Italy, Indonesia, Australia, and India. The microbial community plays a crucial role in managing water quality and providing a sustained supply of supplemental nutrition for the cultivated species. Recent investigations in rapidly urbanizing areas have further interpreted the relationship between efficient resource utilization in BFT and the reduction of carbon emissions (Yao et al., 2023). BFT systems are most effective with species such as tilapia and prawns that can directly consume the floc, leading to significantly increased production output while minimizing negative environmental impacts.

In the late 1980s and 1990s, research in Israel and the USA specifically at the Waddell Mariculture Centre-initiated studies on biofloc technology across multiple species, including *Penaeus monodon*, *Fenneropenaeus merguiensis*, *Litopenaeus vannamei*, and *L. stylirostris*. Their primary focus remained on tilapia and *L. vannamei* prawns. Commercial implementation of BFT first occurred at a farm in Tahiti (French Polynesia) in 1988, demonstrating beneficial features ranging from water quality control to in situ feed production. Currently, carp, catfish, tilapia, and shrimp are the species most commonly cultivated in biofloc systems (Alam and Khan, 2024; Raza et al., 2024). Further refinements in these systems were implemented following subsequent studies (Crab et al., 2012). For instance, the performance of freshwater prawns (*M. rosenbergii*) in low-density biofloc systems showed optimal growth and survival rates when managing stocking densities to maximize productivity.

Research in Bangladesh regarding the giant freshwater prawn, *M. rosenbergii*, demonstrated that biofloc helps reduce dietary protein requirements from 42% to 35% without compromising yield, allowing farmers to adopt more sustainable and cost-effective farming practices (Alam and Khan, 2024). Additionally, a 165-day study at Mindanao State University in the Philippines evaluated the effects of BFT on the water quality and growth performance of *M. rosenbergii*. The postlarvae of *M. rosenbergii* thrived as water parameters remained within the optimum range; interestingly, the technology did not significantly influence the dissolved oxygen, temperature, or pH values of the water and sediment samples (Camarin et al., 2023). These findings highlight the robustness of biofloc technology in maintaining stable aquatic environments for freshwater prawns while improving overall biological efficiency and resource management.

12 Recirculatory Aquaculture System

In recirculatory aquaculture system (RAS) water is recycled and reused after removal of suspended matter and metabolites and is used for high- density culture of various species of fish, utilizing minimum land area and water. It is suitable intensive high density fish culture unlike other aquaculture production systems instead of the