



Drugs and chemicals used for disease control and water quality management in fish farms

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Abstract

In modern fish farming, chemicals play a central role in both treating disease and preventing its onset, which remains the single biggest source of financial loss in the sector. In recent years, a growing array of chemicals and biologically-based products have also been incorporated as feed additives and water-treatment agents to boost production levels. This expanding reliance on chemical inputs has sparked considerable public concern. The substances employed range from various lime formulations and fertilizers to a multitude of commercial products designed to accelerate growth and enhance water quality. Their advantages are numerous: they raise overall production efficiency, cut down on the consumption of other resources, and support higher hatchery yields and more effective feeding regimes. Moreover, they help improve the survival rates of fry and fingerlings until they reach market size, lessen the stress associated with transport, and aid in controlling pathogenic organisms, among many other uses.

Keywords: Lime, aquaculture, zeolite, growth, disease, prebiotics

Introduction

Over the past half-century, the aquaculture sector has experienced explosive growth. By 2022, output hit a record-breaking 130.9 million tonnes, representing a market value of roughly USD 313 billion; this total encompasses a range of farmed aquatic animals, vegetation, and commodities like pearls and shells. However, as the global population continues to climb, meeting the 2013 per-capita consumption benchmark of 19.7 kg (FAO, 2016) [8] necessitates an additional 23 million tonnes of supply to satisfy demand. Within this global landscape, India currently ranks as the world's second-largest aquaculture producer, accounting for 6.30% of total fish production and 5% of international fish trade (DADF, 2016) [5].

Because the potential for further horizontal expansion is constrained, the industry has pivoted toward vertical development, emphasizing the intensification of farming techniques. While these methods which utilize higher stocking densities and a broader array of species aim to boost output, they have inadvertently triggered an increase in disease outbreaks. These pathogens frequently lead to significant morbidity and catastrophic mortality rates, ultimately undermining total production levels. Recent years have seen the industry suffer markedly from these surges in disease, a direct consequence of prioritizing economic yield through hyper-intensive systems. Furthermore, the constant evolution of culture practices and the rising diversity of farmed species have introduced new environmental variables, which can significantly accelerate the emergence and transmission of aquatic pathogens.

The aquaculture industry has become a vital pillar for economic stability, food availability, and employment in emerging economies. This sector has experienced a surge in visibility and development in recent years, largely bolstered by scientific breakthroughs (Macqueen *et al.*, 2020) [14]. The industry's rapid scaling is primarily fuelled by rising consumer appetite for aquatic protein and the implementation of sophisticated technologies (Flourizel *et al.*, 2023) [9]. As a result, producers have increasingly

transitioned toward intensive farming techniques to maximize their harvest outputs (Manan *et al.*, 2023) [15].

Despite this progress, the sector remains vulnerable to substantial output declines, with pathogenic outbreaks representing the most significant threat. These diseases jeopardize the financial stability of fish farmers, leading to widespread income instability and diminished food reserves. Studies suggest that approximately 50% of global production losses are linked to disease-related issues, with developing nations disproportionately affected (Assefa and Abunna, 2018) [1]. Furthermore, the frequent reliance on chemical interventions to combat these outbreaks has drawn criticism due to the potential ecological degradation of local water systems.

To mitigate these risks, industry experts advocate for a multi-faceted approach to disease prevention. Core strategies include upgrading husbandry protocols, enforcing strict biosecurity measures, utilizing genetically resilient breeds, and integrating nutritional boosters and immunostimulants into feed (Meyer, 1991) [16]. Additionally, broader control measures such as vaccination programs, the application of pre- and probiotics, the use of botanical extracts, targeted antimicrobial therapies, and rigorous water treatment are essential for maintaining sustainable and healthy aquatic populations (Kelly and Renukdas, 2020) [12].

Management of water quality and soil treatment

Achieving a successful and profitable harvest relies heavily on the effective management of soil and water conditions. Before stocking, it is essential to prepare the pond by conditioning the environment to ensure proper organic matter mineralization, pH stabilization, and thorough disinfection. To balance water pH and treat the pond bed, various lime-based products are frequently employed, including quick lime (CaO), slaked lime (Ca(OH)₂), and agricultural lime (CaCO₃). Furthermore, specialized aquaculture additives such as Geotox, Zeolite, Bio Aqua, Zeocare, Aquanone, and Zeo prime are widely utilized to

maintain water quality and prepare the pond environment (Sharker *et al.*, 2014) ^[23].

To disinfect and sterilize ponds after they have been properly dried, producers often use potassium permanganate (KMnO₄) or iodine. Additionally, the soil can be revitalized by applying a mixture of lime, zeolite, and porous aluminium silicate. This combination helps neutralize harmful substances while promoting the development of beneficial algae. Because they provide a cost-effective and reliable method for maintaining optimal conditions, these chemical treatments remain the preferred choice among aquaculture farmers.

Disinfectants used in aquaculture industry

Throughout the global aquaculture industry, disinfectants serve a critical role in maintaining operational health. These substances are particularly prevalent in intensive farming systems, with large quantities applied during the grow-out phases of finfish production. While a variety of chemical agents are endorsed for use in hatcheries and aquaculture ponds, their effectiveness can be significantly compromised if the water contains high levels of organic matter. These chemicals are essential for site preparation, the upkeep of equipment, and the maintenance of sanitation protocols throughout the entire production cycle, as well as serving as therapeutic agents when disease outbreaks occur. Common treatments include water purifiers, EDTA, Benzalkonium Chloride (BKC), Aquakleen, bleach, Efinol, and Formalin. Specifically, Formalin is frequently utilized to combat protozoan infections. To manage bacterial pathogens, agents such as BKC and potassium permanganate are standard, while Efinol is often administered to help fish better cope with environmental stress (Mukta and Paramveer, 2018) ^[17]. Other widely adopted disinfectants include sodium hypochlorite, calcium hypochlorite, calcium carbide, calcium oxide, and Na EDTA. Because chlorine acts as the primary active component in many of these products, they are most commonly deployed within hatchery environments, though they are also used to a more limited degree in direct grow-out pond management.

Piscicides and Herbicides

Before stocking a pond, it is essential to prepare the environment by removing invasive aquatic plants and predatory fish species. To manage unwanted fish, farmers often utilize various piscicides, including plant-based options like derris root powder (5–10 ppm), tea seed cake (75–100 ppm), and mahua oil cake (200–250 ppm), or anhydrous ammonia compounds (Mukta and Paramveer 2018) ^[17]. It is important to note that the specific concentration needed for effective eradication depends on the biomass, size, and type of the fish present.

Controlling unwanted vegetation is equally critical, as excessive weed growth can disrupt nutrient levels and diminish oxygen availability in the water column. Furthermore, thick patches of aquatic plants can hinder both the feeding process and the eventual harvesting of the fish. To combat this, farmers typically apply herbicides and algaecides such as Dalapon, 2,4-D, Simazine, Paraquat, Diuron, or various ammonia derivatives at regulated rates. Additionally, substances known as aquanones have been shown to be effective in eliminating both predatory fish and other harmful aquatic organisms (Jilani *et al.*, 2012) ^[11].

Commonly applied therapeutants in aquaculture

The expansion of intensive aquaculture practices has led to a rise in bacterial outbreaks, driving an increased reliance on antimicrobial interventions (Defoirdt *et al.*, 2011) ^[6]. Typically, diseased fish stocks are managed through short-term antibiotic regimens. Regulatory bodies like the FDA have officially sanctioned specific treatments, including florfenicol, oxytetracycline hydrochloride, and combinations such as sulfadimethoxine and ormetoprim, provided that residue levels remain strictly within established maximum residue limits (MRLs). Furthermore, a growing range of vaccines is now commercially available to protect aquatic species against various viral and bacterial pathogens.

To address parasitic issues, the industry frequently utilizes chemical agents such as Emamectin Benzoate, Dipterex, Nuvan, Ectodel (2.8%), Hitek Powder, Paracure-IV, and treatments like Butox Vet and Cliner, the latter two of which see significant market popularity. Fungal infections in fish are typically managed with trifuralin. Specialized applications are also common in hatchery settings, including the use of copper sulphate (0.25–1 ppm) for filamentous bacteria, EDTA (10–15 ppm) for vibriosis via immersion, Treflan (0.1–0.2 ppm) for larval mycosis, and Prefuran (1 ppm) for bacterial necrosis. It is important to note, however, that while many of these substances are approved for general veterinary use, formal authorization for their specific employment in aquaculture remains limited.

Anaesthetics used for Fish

In the field of aquaculture, the application of anaesthesia is vital for reducing physical trauma and physiological stress during fish handling and transport. While its usage remains limited in India, it is cautiously implemented for long-distance transit of broodstock and fish seed. Common agents used for this purpose include clove oil, MS-222 (tricaine), metomidate, 2-phenoxyethanol, benzocaine, isoeugenol, halothane, quinaldine, and lignocaine. Regulations in the United States, as noted by Popovic *et al.*, (2012) ^[21], permit only sodium chloride and MS-222 for use on fish intended for human consumption, necessitating a 21-day withdrawal period post-exposure before the fish can be harvested. Beyond these, substances such as propiscin (which contains etomidate), propofol, and isoeugenol are frequently examined in experimental settings and applied to non-food fish species.

Feed additives used in aquaculture

The evolution of aquaculture practices has shifted away from relying on basic agricultural byproduct feeds toward the adoption of sophisticated, nutritionally complete diets tailored to the specific needs of individual species. This move toward high-quality nutrition has been the primary driver of the industry's expansion. As highlighted by Bharathi *et al.*, (2019) ^[3], the integration of specialized feed additives is crucial for optimizing fish growth and overall well-being. By enhancing productivity and bolstering immunity against pathogens, these additives are essential for fostering a more sustainable aquaculture model.

Modern artificial diets are complex, balancing essential macronutrients such as proteins, fats, and carbohydrates with a diverse array of functional components. These include vital minerals, vitamins, phospholipids, and

carotenoids for pigmentation, alongside preservatives like antioxidants and mold inhibitors to maintain product integrity. Additionally, chemo-attractants are often utilized to increase feed consumption, directly benefiting the survival and development of the stock. Each additive serves a distinct, functional role within the feed formula. For instance, exogenous enzymes and acidifiers are frequently employed to improve nutrient digestibility and neutralize the negative impacts of anti-nutritional factors. Meanwhile, other compounds such as prebiotics, probiotics, phytogenics, and various immunostimulants—are specifically included to improve gastrointestinal health, strengthen stress resilience, and enhance disease resistance (Mukta and Paramveer 2018) ^[17]. Ultimately, these functional additives represent a safe and environmentally conscious approach to advancing modern fish farming.

Growth Promoters

The application of growth promoters is widely recognized for enhancing physiological development, optimizing feed conversion ratios, increasing profitability, and improving overall body composition. Various additives including prebiotics, probiotics, acidifiers, phytobiotics, and synbiotics are utilized for this purpose, with notable examples including Aqua Boost, Megavit Aqua, Biogen, Aqua Savour, Fibosoel, Grow Fast, Orgavit Aqua, AQGrow-G, Fish Vita Plus, AQ Grow-L, Nature Aqua GP, Vitamix, F Aqua, and ACmix. Research suggests that probiotics demonstrate the highest efficacy among these, followed by prebiotics and acidifiers (Hussein *et al.*, 2016) ^[10]. Furthermore, immunostimulants like Aqua Boost are employed to bolster the non-specific immune responses of fish. In larval rearing, some commercial feeds such as micro-encapsulated diets and shrimp flakes have historically integrated antibiotics like chloramphenicol, oxolinic acid, and oxytetracycline to serve as growth-enhancing agents.

Immunostimulants

To booster the inherent, non-specific immunity of aquatic organisms, immunostimulant-based dietary supplements are becoming increasingly vital. Traditionally, the aquaculture sector has relied heavily on disinfectants, chemotherapeutics, and antibiotics to manage disease outbreaks. Unfortunately, these practices carry severe ecological and health risks, including the accumulation of toxins in the environment, bioaccumulation in food chains, and the potential for human exposure to drug residues. Perhaps most concerning is the rampant abuse or improper administration of antibiotics, which has accelerated the evolution of drug-resistant pathogens. Because antibiotics frequently fail to eradicate infections entirely, diseases often resurface, and chemical residues may persist within fish tissues and the surrounding aquatic ecosystem.

Consequently, there is a growing consensus that transitioning from antibiotics to immunostimulants is a safer, more sustainable strategy. Unlike traditional drugs, immunostimulants do not trigger pathogen resistance and do not leave harmful traces in animal tissues. These agents which encompass a diverse array of categories including cytokines, various bacterial products, polysaccharides, and plant or animal-derived extracts act by stimulating the host's own defences. Research indicates successful disease management against a wide range of threats in shrimp and

fish, including bacterial pathogens like *Aeromonas* and *Vibrio* species, viral infections such as hematopoietic necrosis and yellow head disease, and parasitic challenges like *Ichthyophthirius multifiliis* (Mutum and Amom, 2024) ^[20].

Specific compounds, such as glucan, have proven highly effective at activating non-specific immune pathways, thereby increasing resistance to bacterial invasion. Similarly, peptidoglycan has been shown to heighten hemocyte phagocytic activity. Beyond improved disease resistance, these interventions often correlate with superior growth rates, higher survival percentages, and enhanced feed conversion efficiency. Alongside glucan and peptidoglycan, other frequently utilized immunostimulants in modern aquaculture include chitin and chitosan, vitamin A/C, carotenoids, yeast derivatives, levamisole, lentinan, muramyl dipeptide, and various oligosaccharides (Mutum and Amom, 2024) ^[20].

Vaccines

Fish vaccines function by utilizing antigens derived from pathogens, which are treated to neutralize their virulence, thereby stimulating the host's immune system to enhance resistance against infections. Historically, the breakthrough in aquatic immunization occurred in 1942 with the development of the first vaccine targeting *Aeromonas salmonicida* (Ayalew and Abunna, 2018) ^[2]. Beyond providing a robust defence mechanism, vaccines offer a regulatory advantage, as they are significantly simpler to certify and register for use compared to traditional antibiotics (Ayalew and Abunna, 2018) ^[2].

In the modern aquaculture industry, the accessibility of commercial vaccines for viral and bacterial pathogens has improved substantially. The U.S. market saw the debut of the first commercial bacterial fish vaccine in the late 1970s; these early iterations were primarily whole-cell, inactivated immersion treatments designed to mitigate a range of bacterial diseases. Since then, rapid progress in immunology and biotechnology has paved the way for more sophisticated options, such as polyvalent, nano, genetically modified, and recombinant DNA vaccines (Dadar *et al.*, 2017) ^[4].

While immersion delivery has proven effective for both inactivated bacterins and live attenuated versions, the field continues to evolve. Research has explored the potential of DNA vaccines to provide a safer and more potent defence against furunculosis, though these have yet to receive formal field authorization (Muktar *et al.*, 2016) ^[17]. Currently, the commercial landscape for viral protection in aquaculture is primarily dominated by inactivated viral preparations and recombinant protein-based vaccines (Muktar *et al.*, 2016) ^[17].

Probiotics

Integrating probiotics into aquaculture serves as a widely accepted strategy for bolstering both aquatic environmental conditions and the digestive health of farmed species. These supplements, often administered as live, non-pathogenic bacterial cultures or fermented agents rich in extracellular compounds, are staples in modern pond management. The deployment of probiotics offers a range of performance benefits, including the accelerated breakdown of organic waste, better dissolved oxygen levels, and the mitigation of harmful substances like ammonia, hydrogen sulfide, and

nitrites. By maintaining water chemistry specifically by regulating nitrogen and phosphorus levels and balancing algal populations probiotics foster a healthier environment that leads to lower disease prevalence, higher survival rates, and increased overall yield.

Commonly employed microbial strains in these applications include various concentrations of *Bacillus* sp., *Streptococcus faecalis*, *Rhodobacter* sp., and *Rhodococcus* sp. While some studies have suggested that the measurable impact of these additives can occasionally be limited, the broader consensus remains that probiotic use is a highly viable path toward optimizing aquaculture. By improving growth rates, shortening production cycles, and enhancing the final quality of the aquatic harvest, probiotics provide a sustainable alternative for high-tier animal production. Furthermore, research indicates that these treatments pose no significant threats to food safety or ecological stability (Mutum and Amom, 2024) ^[20].

Antibiotics

Within the aquaculture industry, the widespread application of antibiotics serves as a primary strategy for mitigating, managing, and curing bacterial outbreaks (Romero *et al.*, 2012) ^[22]. Globally, these antimicrobial agents are integrated into human medicine, livestock production, and fish farming not only to combat infections but also to act as growth promoters (Du and Liu, 2012) ^[7]. These drugs are generally delivered through medicated feed, though larger specimens may receive direct injections. To maximize therapeutic efficacy, treatment must be initiated during the initial onset of an illness; as a disease progresses, the pathogen concentration rises, and the tendency for infected fish to lose their appetite makes oral delivery significantly less effective.

In India, aquaculture producers rely on a variety of commercial antibiotic formulations for both prophylactic and reactive disease control. Frequently employed substances include erythromycin, oxytetracycline, oxolinic acid, macrolides, quinolones, fluoroquinolones, and various nitrofurans and sulfonamides (e.g., nitrofurans like Furacin or Furanace and sulfamonomethoxine). These are commonly used to combat conditions such as bacterial hemorrhagic septicemia, aeromoniasis, ulceration, and enteric septicemia (specifically *Edwardsiella ictaluri* in catfish) (Lulijwa *et al.*, 2020) ^[13]. Furthermore, the blending of oxytetracycline, sulfadiazine, and trimethoprim remains one of the most prevalent chemical treatments throughout freshwater hatchery and farming operations.

Conclusion

The management of aquatic animal health frequently involves the application of various chemicals and antibiotics. However, farmers often face challenges regarding the appropriate selection, dosage, and administration of these substances, largely due to a deficiency in technical knowledge. While reducing the overall reliance on such chemicals is the most straightforward approach to mitigating their environmental and health risks, other viable strategies exist. These include the implementation of bioremediation, the use of probiotics, immunostimulants, and vaccines, as well as the adoption of alternative therapeutic agents. To effectively minimize the

detrimental impacts of chemical misuse, it is imperative that policymakers, scientists, and researchers collaborate on comprehensive mitigation strategies."

References

1. Assefa A, Abunna F. Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish. *Veterinary Medicine International*, 2018, 1–10.
2. Ayalew, Abunna F. Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish. *Veterinary Medicine International*, 2018.
3. Bharathi A, Cheryl CBT, Rajagopalasamy A, Uma B, Ahilan S, Aanand. Functional feed additives used in fish feeds. *International Journal of Fisheries and Aquatic Studies*, 2019;7(3):44-52.
4. Dadar K, Dhama VN, Vakharia SH, Hoseinifar K, Karthik R, Tiwari R, *et al.* Advances in aquaculture vaccines against fish pathogens: global status and current trends *Reviews in Fisheries Science and Aquaculture*, 2017;25(3):184- 217.
5. DADF. Guidelines - Central Sector Scheme on Blue Revolution: Integrated Development and Management of Fisheries. Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India, India, 2016.
6. Defoirdt P, Sorgeloos P, Bossier. Alternatives to antibiotics for the control of bacterial disease in aquaculture *Current Opinion in Microbiology*, 2011;14(3):251- 258.
7. Du, Liu W. Occurrence, fate, ecotoxicity of antibiotics in agro ecosystems, *A review Agronomy for Sustainable Development*, 2012;32:309-327.
8. FAO. Opportunities and challenges. *The State of World Fisheries and Aquaculture. Food and Agriculture Organization of the United Nations, Rome, Italy, 2016.*
9. Flourizel I, Akpevwé OE, Osijaye GK. Aquaculture advancement in biotechnology: review. *International Journal for Research In Agricultural And Food Science*, 2023;9(2):11-20.
10. Hussein MS, Zaghlool A, Abd El Hakim FN, El Nawsany M, Hanan A, Abo-State. Effect of Different Growth Promoters on Growth Performance, Feed Utilization and Body Composition of Common Carp (*Cyprinus carpio*). *Journal of Fisheries and Aquatic Science*, 2016;11(5):370-377.
11. Jilani AK, Debasish S, Belal MH, Shamsuddin M, Minar MH. Chemicals Used in Freshwater Aquaculture with Special Emphasis to Fish Health Management of Noakhali, Bangladesh. *African Journal of Basic and Applied Sciences*, 2012;4(4):110-114.
12. Kelly AM, Renukdas NN. Disease management of aquatic animals. In Kibenge FSB and Powell MD (Eds.), *Aquaculture Health Management*. Academic Press, 2020, 137-161.
13. Lulijwa EJ, Rupia, Alfaro AC. Antibiotic use in aquaculture, policies and regulation, health and environmental risks: A review of the top 15 major producers. *Reviews in Aquaculture*, 2020;12:640–663.
14. Macqueen DJ, Houston RD, Naish KA, Nichols KM, Olatoye IO, Sever A. *Advances in aquaculture*. Scientific Research Publishing, 2020.

15. Manan H, Jalilah M, Fauzan F, Ikhwanuddin M, Amin-Safwan A, Abdullah NS, *et al.* Recent developments in aquaculture – A review. *Annals of Animal Science*,2023;23(3):663–680.
16. Meyer FP. Aquaculture disease and health management. *Journal of Animal Science*,2091:69(10):4201–4208.
17. Mukta S, Paramveer S. Drugs and chemicals applied in aquaculture industry: A review of commercial availability, recommended dosage and mode of application. *Journal of Entomology and Zoology Studies*,2018:6(6):903-907.
18. Muktar Y, Tesfaye S, Tesfaye B. Present status and future prospects of fish vaccination: a review. *Journal of Veterinary Science and Technology*,2016:7(2):299-309.
19. Murray AG, Peeler EJ. A framework for understanding the potential for emerging diseases in aquaculture. *Prev Vet Med*,2005:67:223-235.
20. Mutum D, Amom M. Drugs and chemicals applied in aquaculture. *Futuristic Trends in Aquaculture*, 2024, 104-124.
21. Popovic NT, Strunjak-Perovic IR, Coz-Rakovac J, Barisic M, Jadan AP, Berakovic P, *et al.* Tricaine methane-sulfonate (MS-222) application in fish anaesthesia. *Journal of Applied Ichthyology*,2012:28(4):553-564.
22. Romero J, Feijoo CG, Navarrete P. Antibiotics in Aquaculture-Use, Abuse and Alternatives. In *Health and Environment in Aquaculture*. Carvalho ED, David GS, Silva RJ, Eds. Tech Open, Rijeka, Croatia, 2012, 159-198.
23. Sharker MR, Sumi KR, Alam MJ, Rahman MM, Ferdous Z, Ali MM, *et al.* Drugs and chemicals used in aquaculture activities for fish health management in the coastal regions of Bangladesh. *International Journal of Life Sciences Biotechnology and Pharma Research*,2014:3(4):49- 58.
24. Walker PJ, Winton JR. Emerging viral diseases of fish and shrimp. *Vet Res*,2010:41:51.