



ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(8): 317-324
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www.thepharmajournal.com

Received: 26-06-2021

Accepted: 29-07-2021

Anwasha Roy

Assistant Professor, School of fisheries, Centurion University of Technology and Management, Odisha, India

Subal Kumar Ghosh

School of fisheries, Centurion University of Technology and Management, Odisha, India

Hauzoukim

School of fisheries, Centurion University of Technology and Management, Odisha, India

Sagarika Swain

School of fisheries, Centurion University of Technology and Management, Odisha, India

Koyel Bhattacharya

West Bengal University of Animal and Fishery Sciences, Faculty of Fishery Sciences, Kolkata, West Bengal, India

Debopriyo Mukherjii

West Bengal University of Animal and Fishery Sciences, Faculty of Fishery Sciences, Kolkata, West Bengal, India

Avisek Bardhan

West Bengal University of Animal and Fishery Sciences, Faculty of Fishery Sciences, Kolkata, West Bengal, India

Corresponding Author

Anwasha Roy

Assistant Professor, School of fisheries, Centurion University of Technology and Management, Odisha, India

Aqua drugs and chemicals used in freshwater aquaculture: A review

Anwasha Roy, Subal Kumar Ghosh, Hauzoukim, Sagarika Swain, Koyel Bhattacharya, Debopriyo Mukherjii and Avisek Bardhan

Abstract

This study provides a quick overview of different drugs and chemicals commonly used in aquaculture sector for treatment and prevention of different diseases. Different types of water/soil treatment products, disinfectants, therapeutants, anaesthetics, feed additives, growth stimulants, vaccines, probiotics and other products are highlighted, as well as their commercial availability and dose recommendations. The present review on the availability and route of administration of chemicals or medications used in fish and shellfish farming has summarised. The emphasis is on providing a clear image of all approved treatments, as well as their suggested dose and dosages, in order to prevent fish farms for facing loss due to disease outbreaks or poor water and soil quality management.

Keywords: Aquaculture, India, antimicrobial agents, chemicals, aqua-medicines, drugs

1. Introduction

Aquaculture is the fastest growing, vibrant food producing sector in the world which plays a major role in the market facility in term of food, nutrition, income, employment as well as in export earnings (Subasinghe *et al.*, 2002). It is presented like to meet the growing demand for fresh water food or seafood and to meet current challenges relating to the ongoing globalization of trade, intensification and diversification of aquaculture, progress in technological innovations for food production, changes in ecological systems and human behaviour, including a greater awareness to protect biodiversity, public health, and the environment. These challenges will lead to increased attention for improving aquaculture practices, and will become an important alternative to overexploitation and modification of aquatic ecosystems caused by capture fisheries. This sector had distributed its origin in the eastern States of India, mainly the states like West Bengal, Assam, Bihar and Odisha (Mishra *et al.*, 2017) [5]. It has largely hinges upon the contribution of formulated feeds, chemicals, aqua-drugs, and antibiotics. Aquaculture drugs and chemicals plays a critical role not only in fish health management but also in important aspects for increasing fish production and its growth, fecundity and decreases the probability of disease occurrence, reduces the loss due to mortality by finally increasing the total production of fish and other commercial aquatic organisms, manipulation and enhancement of reproduction, growth promotion, processing and value addition of the final product (GESAMP, 1997; Subasinghe *et al.*, 1996) [4]. The worldwide usage of aqua-drugs has increased noticeably during the past two decades, coinciding with changes in farming systems and in aspect of intensification of aquaculture practices. Environmental pollution caused by unregulated drug usage in aquatic ecosystems, has become a severe issue in aquaculture and in human health. There are different types of diseases, found in farmed aquatic animals (Karim *et al.*, 1998; BFRI, 1999 and Faruk *et al.*, 2004) [6]. Occurrence of different bacterial, viral, fungal and parasitic diseases have been reported in aquaculture in India (Nayak *et al.*, 2007, Sahoo *et al.*, 2013) [7, 8] and other Asian countries (Bondad-Reantaso *et al.*, 2005, Faruk *et al.*, 2004, Walker and Winton, 2010) [9, 6, 10]. This has led to enhancement in application of a wide range of aqua-medicines, drugs and chemicals in aquaculture to control production loss (Ali *et al.*, 2004, Burrige *et al.*, 2010, Chowdhury *et al.*, 2012, Costello *et al.*, 2001, Jilani *et al.*, 2012, Joshua *et al.*, 2002, Pathak *et al.*, 2000) [12, 13, 14, 15, 16, 18]. Aquaculture has largely contributed upon the contribution of formulated feeds, chemicals, aqua-drugs, and antibiotics. A broad range of drugs and chemicals are used in aquaculture to manage fish health. Usually, the common chemical includes sodium chloride, formalin, malachite green, methylene blue, potassium permanganate,

hydrogen peroxide and glutaraldehyde (Plumb, 1992) [19]. Some approved (by FDA) drugs, which are mostly used in aquaculture are for immersion Chloramine T, Formaline, Hydrozen Peroxide, Oxytetracycline hydrochloride, Tricaine methanesulfonate, in injectable form Chorionic gonadotropin and in feed additive Florfenicol, Oxytetracycline dehydrate and most recent one is sulphamerazine. Most of the farmers are using these chemicals and drugs randomly without knowing their necessity, effective dose, side effects, drug dose regulating point and proper method of application. With present culture practice, the use of some chemicals is widespread; but farmers must be cautious since they produce food for human consumption. The use of chemicals must be adopted only as a last resort. Studies by Mishra *et al.*, 2017 [5] documented as 364 aqua-drugs and chemicals were used, out of which 216 products in Andhra Pradesh, followed by 98 products in Odisha, 28 products in Jharkhand and 22 products in Chhattisgarh. Out of these maximum number (31%) of aqua-medicines, drugs and chemicals used belonged to feed supplements and growth promoters group, followed by probiotics (24%), water quality improvement products (18%), antiseptics and sanitizers (13%), anti-parasitic drugs (10%) and least numbers were antibiotics (4%). For the success of aquaculture, chemicals must be judiciously and responsibly used. Serious concern has been raised by different international organizations over misuse or abuse of these chemicals, often leading to development of Antimicrobial Resistance (AMR) leading to public health hazard (Gesamp (1997) [4], FAO, 2005, Miranda and Zemelman, 2001, OIE, 1999, Romero *et al.*, 2012, Sapkota *et al.*, 2008) [4, 20, 21, 22, 23, 24]. The variety of chemicals used in fish farming as well as in hatchery operations in both freshwater and coastal aquaculture in India, are classified into broad categories which includes piscicides, herbicides, water/soil treatment products, disinfectants, organic fertilizers, inorganic fertilizers, feed additives, therapeutants, antibiotics and anesthetics.

2. Aqua-medicines, Drugs and Chemicals Use in India

2.1 Piscicides and herbicides

Pre-stocking pond management includes a vital aspect regarding eradication of unwanted predatory fishes as well as aquatic weeds. Most commonly used fish piscicides are mahua oil cake (200-250 ppm), tea seed cake (75-100 ppm), derris root powder (5-10 ppm) and other plant derivatives and anhydrous ammonium substances (Mukta and Paramveer, 2018) [25]. Still the dosage used to eliminate predators depends upon type of species and their size and biomass. Some algicides and herbicides are also used in ponds to reduce the abundance of unwanted aquatic plants which commonly includes 2,4-D, Dalapan, Paraquat, Diuron, Simazine and different ammonia derivatives at a recommended dose. Propagation of unnecessary aquatic weeds in pond is a very common problem faced by freshwater aquaculture farmers in India because they pose serious trouble by competing for oxygen and absorb nutrients from the aquatic systems. Aquanone are also used for controlling unwanted fishes as well as other harmful aquatic animals (Jilani *et al.*, 2012) [26].

2.2 Water and soil treating products

Preparation of pond is the first step towards enhancing of the fish production. Soil and water quality management is the key component to get profitable yield. During pre-stocking period, pond water and soil must be treated followed by conditioning

for optimum mineralization of organic matter, adjusting pH, and for disinfection. Mostly used chemicals in this purpose are lime in the form of agricultural lime (CaCO_3), slaked lime ($\text{Ca}(\text{OH})_2$) or un-slaked lime (CaO). It is used to correct pond bottom and stabilize water pH. The amounts of CaCO_3 and $\text{Ca}(\text{OH})_2$ required to adjust different pH are

Lime has also reported to ensure a healthy plankton bloom. Aqua medicines like Geotox, Zeolite, Zeocare, Lime, Bio Aqua, Aquanone, Zeo prime are getting used for the pond preparation and water quality management (Sharker *et al.*, 2014) [27]. Disinfection and sterilization of properly dried ponds are done by using active iodine or potassium permanganate (KMnO_4). Commercially available zeolite and porous aluminium silicate is also applied along with lime for re-activating the soil to stabilize algal growth and to absorb fouling matters. Most commonly used chemicals are of low price with effectiveness in water quality management are preferred by the farmers.

2.3 Disinfectants used for water hygiene

A number of chemical components has been recommended for disinfection of the pond or hatchery environments. They are used in site and equipment preparation, to maintain hygiene throughout the production cycle and, in some cases, to treat disease. But excess organic load in the ponds may result in reduced effect of disinfectant before it creates a significant effect on the pathogens. Bleaching, Aquakleen, BKC, EDTA, Efinol, Formalin, Water cleansers are the drugs used for disease treatment. Formalin is the chemical mostly used to control protozoan disease. Sodium hypochlorite, BKC, calcium carbide, Calcium hypochlorite, calcium oxide and Na-EDTA are commonly used disinfectants. Fish farmers used a variety of chemicals in the treatment of disease or to avoid its occurrence. Most commonly used bacterial disease controlling agent is BKC (Benzal Konium Chloride), potassium permanganate and to increase stress resistance, Efinol can also be used (Mukta and Paramveer, 2018) [25]. Maximum component in this regard contain chlorine as active ingredient. These are applied mostly in hatcheries and also to a limited extent in grow-out ponds, too.

2.4 Therapeutants used

Intensification in aquaculture has led to an incidence of several bacterial diseases resulted to increased application of antimicrobial agents (Defoirdt *et al.*, 2011, 2007). Antibiotics are frequently administered for a specified period as therapeutics to fishes to treat infections. Food and Drug Administration (FDA) has approved Florfenicol, Sulfamerazine, oxytetracycline dihydrate, Oxytetracycline hydrochloride, sulfamerazine as well as a drug combination of Sulfadimethoxine and ormetoprim for use in aquaculture as long as the fish contains less than a mandated maximum residue limit. Parasitic infestations are broadly distributed in freshwater fishes and include single celled protozoan and multi-cellular trematodes, monogeneans, crustaceans and arthropods (Woo, 2006) [29]. The drugs and chemicals frequently used in aquaculture to control parasitic infestations included Nuvan, Butox Vet, Cliner, Ectodel (2.8%), Emamectin Benzoate (EB), Dipterex, Hitek Powder, Paracure-IV etc. Trifuralin used in fungal infections of fishes. Among these Butox Vet and Cliner has comparatively higher market demand than other products. Some selective therapeutants like EDTA for Vibriosis @ 10-15 ppm, Copper sulphate for Filamentous bacterial disease @ 0.25-1 ppm Dip

treatment for 4-6 h, Treflan for Larval myosis @ 0.1-0.2 ppm Bath for 1 day, Prefuran for Bacterial necrosis @ 1 ppm are commonly used in hatchery management practices. However, there has been no official recommendation for use of such products in aquaculture, although many such products have been permitted for use in veterinary animals.

2.5 Anaesthetics

These are chemical or physical agents used as sedative for animals and cause them to progressively lose their mobility, equilibrium, consciousness, to be calm and finally their reflex action. In aquaculture, anesthesia plays a critical role in prevention of mechanical injuries and manipulation stress in fish during handling and transportation. The use of anesthetics in aquaculture in India is rather limited. They are very cautiously used, particularly in the long distance transport of broodstock and fish seed. Most common anesthetic drugs used in fish are MS-222 (Tricaine), benzocaine, isoeugenol, metomi date, 2-phenoxyethanol, Clove oil, Halothane, Lignocaine, and quinaldine (Summer felt and Smith, 1990; Ross and Ross, 2008; Neiffer and Stamper, 2009; Ackerman *et al.*, 2011). Currently, only sodium chloride and MS-222 are approved by the USFDA for use on food fish in the United States, and fish exposed to them, must be held for a minimum of 21 days before harvesting and human consumption (FDA, 2006; EFSA, 2008; AFS 2011; Popovic *et al.*, 2012) [34, 35, 36, 37]. Other anesthetics, like clove oil, isoeugenol, propofol, and Propiscin (active ingredient etomidate) have been evaluated experimentally and are being used in non-food fish as well as in research purposes (Priborsky and Velisek, 2018).

2.6 Feed additives

The increase in growth of aquaculture has been primarily attributed by the development in premium quality feeds. Any quality feed is prepared from suitable and vital feed additives. Recent advancements in functional feed additives are showing good yields to farmers. These functional feed additives improve the growth as well as health performances of the fishes (Bharathi *et al.*, 2019) [40]. They are used for, higher yield and up-regulated resistance to different infectious diseases, which would finally lead to a sustainable aquaculture practice. Again functional feed additives are environment friendly and also do not result in negative impact on aquaculture. Artificial feeds do not only contains protein, carbohydrate and fat, but also contains vitamins, minerals, carotenoid pigments, phospholipids, chemo-attractants, and preservatives, like mould inhibitors and antioxidants as additives which enhance the growth and survival of cultured fishes (Bharathi *et al.*, 2019) [40]. The type and characteristics of these feed additives is varied, and their administration into diet formulations targets to solve a specific purpose. Additives, such as acidifiers, exogenous enzymes, are used to improve fish performance in respect of digestibility of the feed materials, or counteracting the negative effects of anti-nutritional factors present in feed. Other additives, such as probiotics, prebiotics, phyto genics, and immune-stimulants mostly target to improve the gut health, stress and disease resistance capacity (Mukta and Paramveer, 2018) [25].

2.7 Growth promoters

Growth promoters usually improve growth performances, feed utilization, body composition and net financial return. There are different chemicals found which are used as growth inducing agents including probiotics, acidifiers, prebiotics,

synbiotics, phytobioics like Megavit Aqua, Aqua Boost, Biogen, Aqua Savor, Vitamin premix, Fibosol, Grow fast, Orgavit aqua, AQGrow- G, Fish vita plus, AQ Grow-L, Nature Aqua GP, Vitamix, F Aqua, ACmix and many more like this. But among all, probiotics are superior one followed by prebiotic and then acidifiers (Hussein *et al.*, 2016) [41]. Some investigations using chromatographic methods (HPLC and TLC) have reported that many artificial larval feeds, including shrimp flakes and micro-encapsulated diets, are mixed with various antibiotics such as oxytetracycline, oxolinic acid and even chloramphenicol are added to feed as growth promoters.

2.8 Probiotics

Probiotics in aquaculture are an established management tool for improving gut health as well as environmental quality. The common probiotics used in pond management purposes, includes the live bacterial cultures (non-pathogenic organisms) and fermented products rich in extracellular components. The goodness of using probiotics in culture ponds include induced decomposition of organic matter; decrease in phosphorus and nitrogen concentrations; greater algal concentration, better availability of dissolved oxygen; control of ammonia concentration, nitrite, and hydrogen sulphide as well as other toxic gases; lower the probability of disease occurrence and good survival rate and better fish yield. Different studies have shown such positive benefits resultrd after administration of probiotics (Boyd and Gross, 1998; Queiroz and Boyd, 1998; Queiroz *et al.*, 1998) [42, 43]. These probiotics mostly contains different concentration of beneficial bacteria which includes *Bacillus* sp., *Rodobacter* sp., *Rodococcus* sp., *Streptococcus faecalis*, etc. The applications of probiotics can potentiate the benefits of this activity because, as presented in this paper, it offers viable alternatives for the generation of a higher-quality livestock product in terms of size, production time, and health. Any such food associated and environmental safety hazards have not observed by addition of probiotics to aquaculture ponds.

2.9 Immunostimulants

Immunostimulants are dietary additives that enhance the innate (non-specific) deafens mechanisms and increase resistance to specific pathogens (Kajita *et al.*, 1992) [44]. To overcome the disease problem, generally antibiotics, chemotherapeutics and disinfectants are used in aquatic systems, which in turn lead to drug resistance, human carry over, bioaccumulation with huge pollution to the aquatic environment. But most obvious disadvantage of chemical use in aquaculture is that some strains of pathogen become resistant to certain antibiotics due to their overuse or misuse. The antibiotics cannot completely eliminate pathogens and resulting in recurrence of disease. Again, their residues may accumulate in fish flesh and the environment. So, to reduce this problem and to continue a smooth aquaculture practice some scientists has observed that using immunostimulants against infectious diseases is advantageous than using antibiotics because of zero residue retention in tissues and no strain resistance like antibiotics. Immunostimulants can be branched under different agents based on their origin, such as bacterial preparations, polysaccharides, animal or plant extracts, nutritional factors and cytokines (Kajita *et al.*, 1992) [44]. Several pathogens that were controlled successfully by using immunostimulants in fish/shrimp, are bacteria *Aeromonas salmonicida*, *A. hydrophila*, *Vibrio anguillarum*,

V. vulnificus, *V. salmonicida*, *Yersinia ruckeri*, *Streptococcus* spp.; viruses causing infectious like hematopoietic necrosis, yellow head virus, viral hemorrhagic septicemia and parasitic infestation like *Ichthyophthirius multifiliis*. Commonly used immunostimulants are like glucan which has been shown to stimulate the non-specific defence mechanism of aquatic organisms and to enhance protection against bacterial infection. Peptidoglycan has experimentally shown a significant increase in the phagocytic activity of hemocytes. It also causes a vivid increase in growth parameters, survival rate and feed conversion ratio of treated animals. Several products of peptidoglycans have been widely distributed in the Indian market. Other than peptidoglycan and glucan other frequently used immunostimulants used in aquaculture are Muramyl dipeptide, Chitin and Chitosan, Lentinan, Schizophyllan and Oligosaccharide, Levamisole, Yeast derivatives, vitamin A and C, carotenoids.

2.10 Antibiotics

Global utilization of antimicrobials in the production of food animals has been estimated at 63,151 tons in 2010 and it has been estimated to increase by 67% to 105,596 tons by 2030. Usually, antibiotics have been extensively used in aquaculture to avoid, treat as well as management of bacterial diseases (Romero *et al.*, 2012) [23]. Antibiotics are not only utilized in human medicine, but also worldwide in livestock and in aquaculture to treat bacterial infections and or to promote animal growth (Du and Liu, 2012) [45]. To treat any infected fish, antimicrobials are generally applied orally by admixed with feed and injection can be applied to larger fishes. Antibiotics are most likely to be effective when administered at the primitive stages of a disease occurrence. During later stages, they may not be of much effective, as sick fish normally refuse to eat and the pathogenic load increases more. Antibiotics with different trade names are available in Indian market and also used by the farmers in disease management as preventive and control methods. They mostly include Erythromycin, Nitrofurans (Furacin, Furanace), Oxytetracycline, Sulphamonomethoxine (Dimeton), Oxolinic Acid, Macrolides, Quinolones and fluoroquinolones etc and used to treat bacterial infections like red disease or ulcer disease, bacterial hemorrhagic septicaemia and also useful in control of Aeromoniasis, *Pseudomonas* wound infections and control of enteric septicemia of catfish caused by *Edwardsiella ictaluri* strains. Rao *et al.*, 1992 [46] has found Oxytetracycline, Sulfadiazine and Trimethoprim combination was the most popular chemotherapeutants in freshwater aquaculture and hatchery systems.

2.10.1 Approved antibiotics in India

Not all antibiotics that are in anthropogenic or veterinary use are applicable to aquaculture. The USFDA (United States Food and Drug Administration) is responsible to approve the antimicrobials that can be used in aquaculture. In India, authorities like MPEDA and CAA also play a critical role in listing out the safe antibiotics for aquaculture use. The list below denotes all the approved antibiotics that can be used in aquaculture:

2.11 Vaccines

Vaccines are prepared from antigens are derived from pathogens and converted to non-pathogenic by reducing the virulence through various ways which regulates immune response in fish and increase disease resistance capacity. Fish

vaccination was 1st discovered in 1942 against *Aeromonas salmonicida* infection (Roar and Muiswinkel, 2013, Ayalew and Abunna, 2018 Sommerset Ingunn *et al.*, 2005) [48, 49, 50]. Protection at primary level can be attained through vaccination. Again, the licensing and registration of new vaccine is much easy rather than antibiotics (Ayalew and Abunna, 2018) [49]. Recently, there are some commercial vaccines markedly available for infectious bacterial and viral diseases of fish diseases in aquaculture. As per report, the first commercialized fish vaccines were bacterial vaccine, and introduced in the USA in late 1970s (Dadar., *et al.*, 2017; Roar and Muiswinkel, 2013; Ingunn *et al.*, 2005) [51, 48, 52]. These vaccines were inactivated whole-cell immersion vaccines and proved efficient in preventing many bacterial diseases (Ingunn *et al.*, 2005) [52]. Advancement in biotechnology and immunology has led to development and commercialization of many of fish vaccines like recombinant DNA vaccines, Nano vaccines, subunit vaccines, genetically modified vaccines and Polyvalent vaccines (Karen and Scott, 2001, Dadar., *et al.*, 2017) [53, 51]. Among all, the inactivated bacterin vaccines and live attenuated vaccines have been proved to be efficient one by immersion method (Ingunn *et al.*, 2005) [52]. DNA vaccines were also employed experimentally as safer live vaccines with a high level of efficacy against Furunculosis but their approval for use in the field has not yet been approaching (Muktar *et al.*, 2016; Ingunn *et al.*, 2005) [54, 52]. Currently available commercial viral vaccines for aquaculture are inactivated virus vaccines or recombinant protein vaccines. No live attenuated vaccines are currently licensed for using in aquaculture, only one DNA vaccine against IHN (Infectious hematopoietic necrosis) disease is available (Muktar *et al.*, 2016) [54].

3. Mode of drugs administration in aquaculture

Water medication and medicated feeds are the two most common mode for the administration of different chemicals and drugs in aquaculture. Medicating fish through the water route is done mostly when the fish biomass is less, like fry or when adequate oral therapy is not recommended. It is a simple method, where the volume of water must be known to calculate the final concentration of the medicine. Generally, low molecular weight drugs are recommended for water medication as they can be distributed thoroughly throughout the water. Drugs can be absorbed by the fish through their gill epithelia, skin and mucosa and potentially kills pathogens. Medicated feeds are prepared by the addition of a recommended or approved dose of antimicrobial drug to a extruded diet, or the drug may be sprayed or top-coated on the commercial feed. The benefits of in-feed medication include lesser waste as compared to water application. Again it reduces the undesirable exposure of different chemicals in the environment, human health hazard and also to other animals. This is a popular method to treat and prevent disease in large fish population. A limitation of this method is that fish under treatment must have an active feeding rate. Flushing is also a mode of drug application, Where fishes are placed in running water which is not recirculating, such as in a raceway, immersion can be done by flushing, or, this process is sometimes called as California flush, Which indicates shutting off the water flow and medicating the water and, after an interval, restarting the flow and removing the medicated water. Gavaging method is also used in experimental work as oral administration. This method uses a stomach tube, which is attached to a syringe containing a drug, and the drug is

pumped into the stomach of the fish. Fish must be anaesthetised before administration of the drug. This method is rarely used in the aquaculture industry because it requires skilled labour and also stressful to the fish. Injection methods are used extensively for vaccine administration and treating a limited number of fish or valuable fish in a while, but that is labour intensive. The intramuscular, intra-peritoneal, and dorso-median sinus injections are most common routes of injection for fish. Topical application of drugs to fish is rare; it is usually sometimes used to treat skin ulcers on valuable ornamental fishes. Also disease exposed flesh can be covered with antiseptic or antibacterial ointment.

4. Problems in use of drugs and chemicals

The present study has described some problems which is associated with the formal use of drugs and chemicals which included are:

1. Lack of knowledge regarding use of chemicals
2. Lack of clear idea about method of application of drugs and chemicals
3. Indiscriminate use of chemicals

4. Pressure from pharmaceutical companies and pesticide sellers on farmers
5. Require more awareness about the safety issues in using hazardous chemicals
6. Lack of information on the label of chemical about possible hazard
7. Lack of knowledge about residual effect in respect of consumer health and about expiry date.
8. Lack of proper facilities for fish disease diagnosis.
9. Unregulated use of drugs and chemicals than the recommended dose, leads to problems such as excess drug cannot be tolerated by other organisms which can result in serious biodiversity loss of aquatic organisms.

Table 1: Quantity of lime required in pond in respect of pH

Soil pH	Quantity of CaCO ₃ (Ton/Hectare)	Quantity of Ca(OH) ₂ (Ton/Hectare)
> 6	1 - 2	0.5-1.0
5 - 6	2 - 3	1.0-1.5
< 5	3 - 4	1.5-2.5

Table 2: List of chemicals as pond preparation, improve water quality

Sl. No.	Trade name	Recommended Dose	Chemical ingredient
1	Zeolite gold	400-500 g/dec	SiO ₂ Al ₂ O ₃ , Fe ₂ O ₃ , CaO, MgO, Na ₂ O,
2	JV zeolite	6-7/kg/33 dec	SiO ₂ Al ₂ O ₃ , Fe ₂ O ₃ CaO, MgO Na ₂ O
3	Mega zeo	200 g/dec	SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , CaO, MgO, Na ₂ O, K ₂ O, MN
4	Zeolite	400-500 g/dec	SiO ₂ Al ₂ O ₃ , Fe ₂ O ₃ CaO, MgO, Na ₂ O
5	Acme's zeolite	10-15 kg/acre for 3-4 ft depth	SiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , CaO, MgO, NaO
6	Rotenone	15 g/dec/ft depth	C ₂₃ H ₂₂ O ₆
7	Aqua kleen	0.5-1 litre/acre	Brominated Organic Salts, Amino Nitrogen, Benzalconium

Source: Singha *et al.*, 2020

Table 3: List of disinfectants used for pond hygiene

Sl. No.	Trade name	Recommended Dose	Chemical ingredient
1	Virgo	Potassium monopersulphate 50% w/w containing triple salt of hydrogen sulphate and potassium sulphate	0.5-1 kg/acre during pond preparation; Hatcheries: 5-10 ppm for disinfection
2	Germicida	Powder of sodium chloride and salt containing potassium Monopersulphate, potassium hydrogen sulphate	Preparation stage: 1 kg/acre; Grow out stage: 0.5 kg/acre
3	Ecodyne	Polyvinyl pyrrolidone iodine complex with 20% activity, Stabilizers, Emulsifiers	250-350 ml/acre foot of pond water
4	Viranil	Potassium monopersulfate, Potassium sulphate, Potassium hydrogen sulphate, Color: Tartrazine	5-10 g/ton of water in hatchery 1-2 k/acre of pond
5	Citromax	Natural organic compounds, Lactic ferments, Traces of Ascorbic acid, Palmitic acid, Mannose, Glucose, Glycerides, Fatty acids, Amino acids, Citris bioflavonoides, Tocopherols and Carrier	0.5 g/kg of feed on daily basis for normal application. In case of bacterial or fungal infection-1 g/kg of feed for 5 days
6	Bionex-80	Alkyl dimethyl benzyl ammonium chloride: 80%	Shrimp pond: (<5 gm size): 500 ml-1 l/acre, >5 gm size: 1-2 l/acre Fish pond: 1-2 l/acre
7	Potassium permanganate	Potassium permanganate	20 g/10l water and spray or dip treat
8	Malachite green (M.S)	Malachite Green	Dip: 66.7-100 mg/l, Bath: 6.7 mg/l
9	Formaldehyde solution-37-41% w/v	A colourless aqueous solution of formaldehyde in deionized water stabilized with 15% methyl alcohol	For prolonged bath: 15-25 mg/l For short term bath: 250 mg/l or 1 ml/gallon of water
10	BKC plus	Dimethyl Benzyle ammonium chloride-50%	1 l/acre

Source: Mishra *et al.*, 2017^[5]

Table 4: List of therapeutants used for pond hygiene

Sl. No.	Trade name	Active Ingredient	Dosage
1	Nuvan	Dichlorvos tech. 83.0%, Xylene 8.0%, Epichlorohydrin 1.0%, Emulsifier 7.0%, Triethanolamine 0.9%, Methylene Blue 0.1%	150 to 250 ml per acre
2	Paramed	Pentapropyl methyl-thio-benzimidazole carbamate 5%	1-1.2 k/ton feed for 3 Days
3	Butox Vet	(Deltamethrin 1.25%)	20-30 ml/acre
4	Clinar	Cypermethrin	20-30 ml/acre meter of water
5	Copper (II) Sulfate pentahydrate pure	Copper sulphate	1:2000 with water/acre

6	Bancoxy-K	Amprolium hydrochloride 20% w/w, Menodione sodium bisulphite (0.2%)	30 g in 25-30 litres of drinking water
7	BROFINTM 5%	Bromine 5% w/v	5 l/Ha
8	Paracure – I.V	Ivermectin: 2% w/w	250 gm per ton of feed for 4 days
9	Dichlorvos-E.C. 76%	Dichlorvos-76%	150-250 ml/acre

Source: Mishra *et al.*, 2017^[5]

Table 5: List of different feed additives and growth promoters used in aquaculture

Sl. No.	Trade name	Active Ingredient	Dosage
1	Frankzole	Vitamin-A, D3, E, K3, C, B1, B2, B4, B12, Folic acid Biotin, DL-methionine, L-Lysine, Inositol, Zn, Co, Se, SiO ₂	1 k/acre
2	Liv-52 Protec	Each 10 ml contains: extracts of Sarapunka-47.5 mg, Bhumyamalaki-43.75 mg, Arjuna-33.75 mg, Yavatikta-31.25 mg, Kakamachi-25 mg, Nimba-25 mg, Punarnava-25 mg, Bhringaraja-18.75 mg	Fish/Shrimp- 20 ml/k feed (up to 10 week age) 50 ml/k feed
3	Star Shrimp	Growth promoter of organic chelated essential macro and trace minerals in organic form (Ca, P, K, Na, Cl, Mg, S, Zn, Fe, Co, Cu, Mn)	Shrimp: 10 g per 1 k feed. 1-2 days before and after moulting Fish: 500 g - 2 k/ton feed
4	Venribee-Plus	Vit B-Complex with Vit-E	20-2 g/100 k fed
5	Grovit-C	Each gram contains vitamin-C 500 mg stabilizers anti oxidants and proper base	1 to 1.5 g/kg feed
6	K-Max	Enriched Potassium, Chloride and other nutrients	During culture-10 to 20 k/ha/week
7	Growel	Vitamins like A, E, D3, B1, B2, B6, B12, Niacin, Pantothenic acid, Folic Acid, Vitamin-C etc.	Shrimp- 5 to 8 g/k of feed regularly
8	Agmin Forte	Vit-A=7 lakh IU, D3=70000 IU, E=250 mg, Nicotinamide-1 mg, Co-150 mg, Cu-1200 mg, I2-325 mg, Fe-1500 mg, Mg-6000 mg, Mn-1500 mg	1 k-2 kg to be mixed in 1000 k feed
9	Envo Min	Complex mixture of essential micronutrients in inert form with Calcium, Magnesium, Phosphorus, Sodium and Potassium. Enrich with Ammonia Acids and high quality growth promoters.	Culture: 10 -15 g/k of feed For pond preparation: 25 k/acre
10	Aqua Vit-C	Bio available coated Vitamin-C	Shrimp: 1.0 g/k feed
11	Osmin	Ca=30%, P=9%, Mg=0.12%, Fe=0.6%, I2=0.1%, Cu=0.02%, Chloride=0.05%, Zn=0.2%, Lysine=0.2%, D-methionine=1.92%, Thiamine=50 mg, Riboflavin=66 mg, Niacin=330 mg, Vit B6=26.67 mg, Folic acid=2000 mcg, Vit B12=10 mcg, Biotin=500 mcg, Pantothenic acid=20 mg, Chitosan=12 g	5-10 g/k of feed
12	Lipidex	Lipids and Amino acids, Vitamin A, C, E, B12, Liver oil	20 ml/k of feed

Table 6: List of FDA approved antibiotics

Antibiotics approved	Particulars	Route of administration with proper dosage
Chloramine-T	For the control of mortality in freshwater-reared salmonids due to bacterial gill disease and columnaris associated with <i>Flavobacterium</i> spp.	Immersion (20 mg/L for 60 minutes every alternated day as many as 3 times)
Oxytetracycline hydrochloride (Terramycin343; Oxymarine™)	Used in finfish fry and fingerlings.	Immersion (200-700 mg/L water for 2-6 hours)
Oxytetracycline dihydrate (Terramycin®)	1. For the control of gaffkemia caused by <i>Aerococcus viridans</i> . 2. For the control of mortality in freshwater-reared salmonids due to coldwater disease associated with <i>Flavobacterium psychrophilum</i> . 3. For the control of mortality in freshwater-reared <i>Oncorhynchus mykiss</i> due to columnaris associated with <i>Flavobacterium columnare</i> .	2.50-3.75 g/100 lb fish
Florfenicol (Aquaflor®)	1. For the control of mortality in catfish due to enteric septicemia of catfish associated with <i>Edwardsiella ictaluri</i> . 2. For the control of mortality in freshwater-reared salmonids due to coldwater disease associated with <i>Flavobacterium psychrophilum</i> . 3. For the control of mortality in freshwater-reared salmonids due to furunculosis associated with <i>Aeromonas salmonicida</i> . 4. For the control of mortality due to columnaris disease associated with <i>Flavobacterium columnare</i> in freshwater-reared finfish and for the control of mortality due to streptococcal septicemia associated with <i>Streptococcus iniae</i> in freshwater-reared warmwater finfish.	Medicated Feeds (10 mg/kg fish/day for 10 days)
Sulfadimethoxine/ormetoprim (Romet-30®)	1. For the control of furunculosis in salmonids (trout and salmon) caused by <i>Aeromonas salmonicida</i> . 2. For the control of bacterial infections in catfish caused by <i>Edwardsiella ictaluri</i> (enteric septicemia of catfish).	Medicated feeds (50 mg/kg fish BW for 5 days consecutively)
Sulfamerazine fish grade	Not currently marketed	NA

FDA Approved Aquaculture Drugs (permitted for application in fisheries and aquaculture)

Source: US FDA, 2017. Approved Aquaculture Drugs, U.S. Food and Drug Administration

5. Conclusion

Considering the present scenario, it can be concluded that further development of the aquaculture industry, particularly in intensified aquaculture system, the applications of chemicals and drugs has been increased. This study has described different types of aquaculture drugs and chemicals with their action which are used in fish growth and health management by the fish farmers. This study also demonstrated the recent status of drugs and chemicals using in aquaculture sector and also reflected some problems of the use of different chemicals and drugs by the farmers as well as different supplier agencies which include lack of knowledge on chemical usage, doses and methods of application and their actions. Also there are some alternatives available to reduce the deleterious effects of chemicals which are used very rarely

in aquaculture sector. These alternatives are used as bioremediation and listed as probiotics, immunostimulants, vaccines and alternative therapeutics to prevent and treat diseases. However, policy makers, researchers and scientists should collaborate and work in addressing the issues of chemical usage in aquaculture with a view to reduce the negative impacts. Therefore, both the government and nongovernment organizations should take some initiative for better understanding of chemical and drug use and usage in aquaculture management.

6. References

1. Subasinghe RP, Barg U, Tacon A. Chemicals in Asian aquaculture: need, usage, issues and challenges 1998.
2. Arthur JR, Lavilla-Pitogo CR, Subasinghe RP (eds.). Use

- of Chemicals in Aquaculture in Asia. Southeast Asian Fisheries Development Center, Aquaculture Department, Asia, Philippines.
3. Mohan CV, Bhatta R. Social and economic impacts of aquatic animal health problems on aquaculture in India 2002.
 4. Gesamp. Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Pullin RSV, Rosenthal H, Maclean JH (eds.). Towards safe and effective use of chemicals in coastal aquaculture. Geneva, Switzerland 1997.
 5. Mishra SS, Das R, Das BK, Choudhary P, Rathod R *et al.*, Status of Aqua-medicines, Drugs and Chemicals Use in India: A Survey Report. J Aquac Fisheries 2017, 1(004).
 6. Faruk MAR, Alam MJ, Sarker MMR, Kabir MB. Status of fish disease and health management practices in rural freshwater aquaculture of Bangladesh, Pakistan J Biol. Sci 2004;7(12):2092-2098.
 7. Nayak SK, Swain P, Mukherjee SC. Effect of dietary supplementation of probiotic and vitamin C on the immune response of Indian major carp, *Labeo rohita* (Ham.). Fish Shellfish Immunol 2007;23:892-896.
 8. Sahoo PK, Mohanty J, Garnayak JSK, Mohanty BR, Kar Banya *et al.*, Estimation of loss due to argulosis in carp culture ponds in India. Indian Journal of Fisheries 2013.
 9. Bondad-Reantaso MG, Subasinghe RP, Arthur JR, Ogawa K, Chinabut S *et al.*, Disease and health management in Asian aquaculture. Vet Parasitol 2005;132:249-272.
 10. Walker PJ, Winton JR. Emerging viral diseases of fish and shrimp Vet Res 2010;41:51.
 11. Ali MM, Rahman MA, Hossain MB, Rahman MZ. Aquaculture Drugs used for Fish and Shellfish Health Management in the Southwestern Bangladesh. Asian Journal of Biological Sciences 2014;7:225-232.
 12. Burrige L, Weis JS, Cabello F, Pizarro J, Bostick K. Chemical use in salmon aquaculture: A review of current practices and possible environmental effects. Aquaculture 2010;306:7-23.
 13. Chowdhury AKJ, Saha D, Hossain MB, Shamsuddin M, Minar MH. Chemicals Used in Freshwater Aquaculture with Special Emphasis to Fish Health Management of Noakhali, Bangladesh. African Journal of Basic & Applied Sciences 2012;4:110-114.
 14. Costello BMJ, Grant A, Davies IM, Cecchini S, Papoutsoglou S *et al.*, The control of chemicals used in aquaculture. European Journal of Applied Ichthyology 2001;17:173-180.
 15. 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 & Applied Sciences 2012;4:110-114.
 16. Joshua K, Sujathat A, Ramana LV, Carolin E, Supraba V *et al.*, Use of various chemicals in shrimp hatcheries and its sustainability in hatchery technology. Paper presented in National Workshop on Aquaculture Drugs, January 2002, 18-20.
 17. CFDDM. Cochin University of Science and Technology, Cochin, Kerala, India.
 18. Pathak SC, Ghosh SK, Palanisamy K. The use of chemicals in aquaculture in India. Southeast Asian Fisheries Development Center, Iloilo, Philippines 2002.
 19. Plumb JA. Disease Control in Aquaculture. In: Shariff IM, Subasinghe RP, Arthur JR (eds.). Disease in Asian Aquaculture I. Fish Health Section, Asian Fisheries Society, Manila, Philippine 1992.
 20. FAO. Responsible Use of Antibiotics in Aquaculture. FAO Fisheries Technical Paper. Food and Agriculture Organization of the United Nations, Rome, Italy 2005.
 21. Miranda CD, Zemelman R. Antibiotic resistant bacteria in fish from the Concepción Bay, Chile. Mar Pollut Bull 2001;42:1096-1102.
 22. OIE. European Scientific Conference on the use of Antibiotics in Animals: Ensuring the Protection of Public Health. March 1999, 24-26. Paris.
 23. Romero J, Feijoo CG, Navarrete P. Antibiotics in Aquaculture-Use, Abuse and Alternatives. In: Carvalho ED, David GS, Silva RJ (eds.). Health and Environment in Aquaculture. In Tech Open, Rijeka, Croatia 2012.
 24. Sapkota A, Sapkota AR, Kucharski M, Burke J, McKenzie S *et al.*, Aquaculture practices and potential human health risks: current knowledge and future priorities. Environ Int 2008;34:1215-1226.
 25. 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.
 26. 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 & Applied Sciences 2012;4(4):110-114.
 27. Sharker MR, Sumi KR, Alam MJ, Rahman MM, Ferdous Z *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;3:49-58.
 28. Tom D, Patrick S, Peter B. Alternatives to antibiotics for the control of bacterial disease in aquaculture. Current Opinion in Microbiology 2011;14:251-258.
 29. Woo PTK. Fish Diseases and Disorders, (2nd edn). Protozoan and Metazoan Infections. Cambridge USA 2006.
 30. Summerfelt RC, Smith LS. Methods for fish biology. In: Anaesthesia, surgery and related techniques. (Schreck, C. B., and P. B. Moyle, Eds.) Bethesda: American Fisheries Society 1990, 213-272.
 31. Ross LG, Ross B. Anaesthetic & Sedative techniques for aquatic animals. Wiley-Blackwell 2008.
 32. Neiffer DL, Stamper MA. Fish sedation, anesthesia, analgesia, and euthanasia: considerations, methods, and types of drugs. J Inst. Lab. Anim. Res 2009;50:343-360. doi:10.1093/ilar.50.4.343.
 33. Ackerman PA, Morgan JD, Iwama GK. Anesthetics. CCAC guidelines on: the care and use of fish in research, teaching and testing. Ottawa CA: Canadian Council on Animal Care 2005.
 34. FDA (U.S. Food and Drug Administration). Database of approved animal drug products. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Veterinary Medicine. VMRCVM Drug Information Laboratory 2006.
 35. EFSA (European Food Safety Authority). Scientific report of EFSA prepared by Working Group on seabass/seabream welfare on Animal Welfare Aspects of

- Husbandry Systems for Farmed European seabass and gilthead seabream. Annex I to. EFSA J 2008;844:1-89.
36. AFS (American Fisheries Society). Guide to using drugs, biologics, and other chemicals in aquaculture, FCS Working Group on Aquaculture Drugs, Chemicals, and Biologics, February 2011, 65.
 37. Popovic NT, Strunjak-Perovic IR, Coz-Rakovac J, Barisic M, Jadan AP, Berakovic *et al.* Klobucar, Tricaine methane-sulfonate (MS-222) application in fish anaesthesia. J Appl. Ichthyol 2012;28:553-564. doi:10.1111/j.1439-0426.2012.01950.x.
 38. Priborsky JA, Stara J, Rezabek E, Zuskova P, Lepic, Velisek J. Comparison of the effect of four anesthetics on haematological profile, oxidative stress and antioxidant enzymes in barbel (*Barbus barbus*). Neuroendocrinol. Lett 2015;36(1):141-146.
 39. Suranjit S, Tasnim S, Nazmun NR, Md. Robiul H, Ahsan H. Asian Journal of Biology 2020;10(4):22-31. Article no.AJOB.63384 ISSN: 2456-7124
 40. Bharathi S, Cheryl A, Rajagopalasamy CBT, Uma A, Ahilan B, Aanand S. Functional feed additives used in fish feeds. International Journal of Fisheries and Aquatic Studies 2019;7(3):44-52.
 41. Mohsen Hussein S, Ahmed Zaghlool, Nabil Abd El Hakim F, Mohamed El Nawsany, 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.
 42. Boyd CE, Tucker CS. Pond Aquaculture Water Quality Management, Kluwer, Norwell, Mass, USA 1998.
 43. Queiroz JF, Boyd CE. Effects of a bacterial inoculums in channel catfish ponds, Journal of the World Aquaculture Society 1998;29(1):67-73.
 44. Kajita Y, Sakai M, Atsuta S, Kobayashi M. Immunopotential activity of Freund's complete adjuvant in rainbow trout *Oncorhynchus mykiss*. Nippon Suisan Gakkaishi 1992;58:433-437.
 45. Du L, Liu W, Occurrence, fate, ecotoxicity of antibiotics in agro ecosystems. A review. Agron. Sustain. Dev 2012;32:309-327. doi: 10.1007/s13593-011-0062-9
 46. Rao KG, Mohan CV, Seenappa D. The use of chemotherapeutic agents in fish culture in India. In: Shariff M, Subasinghe RP, Arthur JR (eds.). Diseases in Asian aquaculture. Fish Health Section, Asian Fisheries Society, Manila, Philippines 1992.
 47. Novel Drug Approvals for USFDA 2017. Accessed on: 01.06.2021
 48. Gudding R, Willem Muiswinkel V. A history of fish vaccination: science-based disease prevention in aquaculture. Fish and Shellfish Immunology 2013;35(6):1683-1688.
 49. Assefa Ayalew, Fufa Abunna. Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish. Veterinary medicine international 2018.
 50. Sommerset Ingunn *et al.* Vaccines for fish in aquaculture. Expert Review of Vaccines 2005;4(1):89-101.
 51. Dadar *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.
 52. Sommerset Ingunn *et al.* Vaccines for fish in aquaculture. Expert Review of Vaccines 2005;4(1):89-101.
 53. Plant KP, Scott LaPatra E. Advances in fish vaccine delivery. Developmental and Comparative Immunology 2011;35(12):1256-1262.
 54. Muktar Y *et al.* Present status and future prospects of fish vaccination: a review. Journal of Veterinary Science and Technology 2016;2:299.