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Research Article

Status of Aqua-medicines, Drugs and Chemicals Use in India: A Survey Report

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Abstract

Survey was performed to assess the availability and use of different commercial grade aqua-medicines, drugs and chemicals in aquaculture activities in the selected key districts of four aquaculture dominant states of India viz., Andhra Pradesh, Odisha, Jharkhand and Chhattisgarh. A total of 265 farms, 36 aqua shops, and 18 drug manufacturer units were surveyed and information collected. Data were collected through stratified random sampling techniques using key Participatory Rural Appraisal (PRA) tools like standard questionnaire, personal interview, market survey, and group discussion, fish health camp and awareness programme with fish farmers, entrepreneurs and fish seed hatchery owners. Besides these views of State Fishery Departmental staff, retailers of aqua-medicines, drug inspectors and representatives of pharmaceutical companies were also taken. Six categories of aqua drugs and chemicals were found to be used by the fish farmers and hatchery owners which included those used for i) water quality management, ii) anti-parasitic drugs, iii) disinfectants or sanitizers, iv) water and feed probiotics, v) feed supplements and growth promoters and vi) antibiotics. Highest proportions of products used in aquaculture were assessed to be those used for feed supplements and growth promoters (31%) followed by water and feed probiotics (24%). Other products included were those chemicals and formulations used for water quality management (18%), disinfectants and sanitizers (13%), anti-parasitic drugs (10%) and antibiotics (4%). Furthermore, the survey revealed most farmers and end users lack knowledge and information on the quality and utility of such aqua-drugs and chemicals and they are mostly dependent on local consultants or representatives for their application in aquaculture. Again, some of the drugs and chemicals used in animal medicine and agricultural practices have made their way in aquaculture application. Besides these, various other anthropogenic activities have led to release of large quantities of drugs, chemicals, pesticides and antibiotics into aquatic system, mainly through human wastes and agricultural runoff. Unregulated use of such antibiotics and chemicals may lead to development and spread of antimicrobial resistant bacteria and all that may induce a negative impact on human, fish and the environment. So, the policy makers, researchers and scientists should work together in addressing the issues of irrational use of such drugs and chemicals in aquaculture with the view to lessen the unseen impacts on aquaculture in future days.

Keywords: Antibiotics; Aquaculture; Aqua-medicines; Chemicals; Drugs; Fish culture; Shrimp farming

Introduction

Fisheries has been an age old practice in India and has become an important economic activity. Aquaculture had its origin in the eastern States of India, mainly in states like West Bengal, Assam, Bihar and Odisha. The culture practices were restricted to the homestead ponds with traditional methods and for their family requirement. The traditional system of yester years fisheries, gradually developed into modern methods of aquaculture in India [1]. The vibrancy of the sector can be assessed by nearly 11-fold increase in fish production in just six decades, i.e., from 0.75 million tonnes in 1950-51 to 9.6 million tonnes during 2012-2013 [2]. Aquaculture is now integral to the economies of many states, providing livelihood security to rural poor, mainly in coastal communities [3]. This has relieved pressure on capture fisheries, harvest of wild stock from rivers, lakes, oceans and other open-water resources [3-4]. Fish has a nutritional profile superior to all terrestrial meat, being an excellent source of high quality animal protein and highly digestible energy, as well as an extremely rich source of omega-3 polyunsaturated fatty acids. At present, fish represents the primary and cheap source of animal protein, contributing more than 25% of the total animal protein supply for about one billion people worldwide [5].

In recent years, there has been a noteworthy expansion of aquaculture in India. Much of this development has been focused on states like Andhra Pradesh, Odisha, West Bengal, Karnataka, Tamil Nadu and Punjab, where commercial carp culture is gaining momentum. In Andhra Pradesh, commercial aquaculture was initiated in the Kolleru lake region of Andhra Pradesh and recent growth of the sector around Kolleru lake and the surrounding districts like in East Godavari, West Godavari and Krishna, has put this region as the epicentre of Indian aquaculture. Besides, modern aquaculture has made rapid growth in eastern part of India like in Odisha, West Bengal, Bihar, Chhattisgarh and Jharkhand states. With the increase in aquaculture practices leading to enhanced fish production, aquatic animals have come across a series of health menaces due to environmental stress, incursion of infectious pathogens and increased incidence of fish disease outbreaks [6,7]. Incidence of different bacterial, viral, fungal and parasitic diseases have been reported in aquaculture in India [8,9] and other Asian

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countries [5,10-11]. This has led to enhancement in application of a wide range of aqua–medicines, drugs and chemicals in aquaculture to control production loss [12-18]. Besides their use in fish health management, aquaculture drugs and chemicals play key role in various other aquaculture activities like in pond construction, soil and water management, enhancement of natural aquatic productivity, feed formulation and growth [19-23]. A large numbers so called aquaculture consultants and representatives of pharmaceuticals and feed companies and chemical sellers are involved in marketing chain, for delivery of such products to end users [24]. 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 [21,25-29]. However, so far no appropriate research or systematic survey have been carried out in India, to understand the marketing and availability of various aqua-medicines, drugs and chemicals for application in aquaculture. Therefore, the present survey was carried out to assess the market availability and use pattern of various aqua-medicines, drugs, chemicals and formulations in major aquaculture zones in India and to understand the linkage between drug producers, consultants and fish farmers. Besides these, efforts have been made to review and correlate aqua-drugs and chemicals use pattern in other aquaculture producing nations and guidelines of international organizations on responsible use of such drugs and chemicals in aquaculture.

Materials and Methods

Study area

Data for the present survey were collected for a period of two year from aquaculture dominant states in India viz., Andhra Pradesh, Odisha, Jharkhand and Chhattisgarh. In Odisha, nine districts viz., Khurda, Puri, Kendrapada, Cuttack, Angul, Sambalpur, Balasore, Mayurbhanj, Bhadrak and in Andhra Pradesh, Vizianagaram, Srikakulam, Vijayawada, Gudiwada, Eluru, East Godavari, West Godavari and Krishna districts and aquaculture zones were surveyed. In Jharkhand state, extensive survey were made in Ranchi, Durg, Sahibganj, Chandil and in Chhattisgarh state, Raipur, Durg and Raigarh were surveyed. Information was also collected from State Government Fishery Departments in each state. A total of 265 farms, 36 aqua shops, and 18 drug manufacturer units were surveyed and information collected.

Data collection and analysis

Both primary and secondary data were used during the study. Primary data were collected through field surveys in different districts and aquaculture zones, to have on spot assessment. Specific prescribed questionnaire "Survey on usage pattern of drugs and chemicals in Indian aquaculture under All India Network Project on Fish Health" was used for survey. Data were collected through interview and personal interaction with fish farmers, hatchery operators, aqua-shop owners, fish disease consultants and representative of pharmaceuticals and feed companies. Data on use of chemicals, active ingredients of aqua-medicines, their indications, method of application, dose, effectiveness, duration of application, cost and effect on environment were collected and compiled. Secondary source of information consisted of published reports, training material, newsletters of aquaculture production firms, non-government organizations, appropriate government organizations like Marine Products Export Development Authority (MPEDA), Coastal Aquaculture Authority (CAA) etc. Data was collected through Participatory Rural Appraisal (PRA) and conduct of Fish Health- Awareness Programme and Kissan Gosthi at selected aquaculture zones. The data were further analyzed using tabular and descriptive statistical techniques.

Results and Discussion

With the increase in demand of fish production and intensive methods of fish culture, aquatic animals come across a series of health hazards mainly due to deterioration of environmental condition, stress and incursion of infectious agents. At the same time, there has been over-exploitation of fisheries from open water resources that has placed pressure on wild fish populations. The consequences of these impacts have been emergence and spread of an increasing array of fish diseases, having impact on fish production and productivity [11]. This has led the farmers and hatchery owners adopt a variety of measures including application of aqua-medicines, drugs and chemicals in aquaculture system as preventive and control measure to minimize production loss. Preventive measures constitute the core of disease control programme, including environmental manipulation, proper nutrition and immunological protection. Treatment is usually in form of chemotherapy to be considered as last resort in disease control [30]. The aqua-medicine use patterns have been different in different regions depending on culture practices, species used and economics expected. In the present case, a total of 265 fish farms, 36 aqua-shops, and 18 drug manufacturer units were surveyed and information collected on 364 aqua-medicines, drugs and chemicals. It was observed that in active aquaculture zones, various types infectious diseases such as bacterial red disease, gill disease, swollen abdomen, Epizootic Ulcerative Syndrome EUS), parasitic diseases like argulosis, gill flukes, and few protozoans like Ichthyophthiriasis, Ich and *Myxobollus sp.* were found affecting Indian Major Carps (IMCs) viz. rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), and other species like sharputi (*Puntius sarana*), and silver carp (*Hypophthalmicthys molitrix*) as also previously reported by other researchers [6,7,9]. Farmers in the regions use different antibacterial, antiseptics and water sanitizers to control disease and minimize production loss. Again, various pesticides and insecticides were being used to control fish parasitic infestations, which have been a major cause of concern in entire region. Different authors have also reported use of various such drugs, chemicals, feed supplements in aquaculture practices for prevention of disease and enhance production [10,16,19,21] and for health management in hatcheries [15,17,18,23] Apart from antibiotics, some common chemicals reported being used in aquaculture included sodium chloride, formalin, malachite green, methylene blue, potassium permanganate, hydrogen peroxide and glutaraldehyde [18,22]. Besides disease control, many aquaculture drugs have significant application in pond construction, soil and water management, to improve aquatic productivity, feed formulation, manipulation of reproduction, growth promotion and processing and value addition of the final product [12,14,20,23]. Most of the aqua-products commercially available for use in aquaculture could be categorized in to six types, i) Those chemicals and formulations for water quality management ii) Anti-parasitic drugs and chemicals iii) Disinfectants and sanitizers iv) Probiotics and water remediation products (Feed/soil/water probiotics), v) Feed Supplements including growth promoters and vi) Antibiotics.

In the present survey, it was observed that a wide variety of chemicals and formulations were available in the market, recommended for

maintenance of water quality and pond management in aquaculture. The list of such chemicals with their active ingredients have been presented in table 1. Pond preparation is vital to enhance the productivity of the system. Again, maintenance of optimum water quality is very crucial in determining the success and failure of the fish production to a great extent which includes pH, total alkalinity, total hardness, Dissolved Oxygen (DO), ammonia, and nitrite-nitrate concentration. In the survey region, different chemicals like Addoxy, Aqualite, Clinzex-DS, Earth, Halonex, Odoban-A30 etc. were commonly used in pond preparation process and for maintenance of optimum water quality. Whereas Ammocurb, Ammo Trap, Bio Curb, De-Odorase, De-Odr and Toximar were used for removal of ammonia from water and sediment, O_2 MAX, Oxycal and Oxy-Gen were used for DO maintenance. The range of such products used in shrimp culture were more than that used in carp culture. It was noted that most of these products were imported in bulk by the local firms from other Asian counties like China, Thailand and Singapore, which were then repacked and marketed as different brands with variable compositions. In aquaculture, maintaining optimum DO concentration (3-6 ppm) in the culture ponds is most important in cloudy weather, post-monsoon and during winter season, as many cases of fish-kills are recorded due to this single factor. Hence fish farmers need to know the required water treatment processes to control temperature, DO, pH, and dissolved nitrogen compound (ammonia, nitrate and nitrite) levels in the culture water for optimal growth of aquatic animals [31].

Although, there are no published reports available on use of such aqua –drugs, chemicals and formulations in aquaculture in other counties, Ali et al., [12] reported use of Geotox, Zeolite, Zeocare, Lime, MegaZeo, Bio Aqua, Aquanone, Zeo prime for the pond preparation and water quality management by different farmers in Bangladesh. Aquanone were used for controlling unwanted fishes as well as other harmful aquatic animals. Jilani et al., [16] reported that lime, zeolite, fish toxin, insecticides and different fertilizers were used for the preparation and water quality management in Noakhali district. Lime was the most commonly used chemical used in fish culture in Bangladesh [24], as also observed in the present survey. Sharker et al., [24] also noted that most chemicals were used for oxygen supply like Bio-ox, Best oxygen, Oxygen plus, Oxyflow, Oxylife, Oxymax, Oxymore and Oxyplus. Oxydizing agent, hydrogen peroxide was the major active ingredient of such products. Faruk et al., [10,20] observed that oxymax was commonly used to remove hardness and toxic gases in fish culture ponds.

Among fish diseases, parasitic infestations are major cause of concern in semi-intensive and extensive fish culture system. Ectoparasites are widely distributed infectious agent in freshwater fish which include single celled protozoan and multi-cellular trematodes, crustaceans and arthropods [32]. These parasites induce high morbidity, retard growth and reduce the market value of both food fish and ornamental. Wide ranges of chemicals or formulations are being used by the fish farmers for the treatment of parasitic infestations caused by fish louse (*Argulus spp*.), gill flukes (*Dactylogyrus sp*.), *Myxobolllus sp*., ich (*Ichthyophtherius sp*.) and gill maggot (*Ergasillus sp.*). The drugs and chemicals commonly used to control parasitic infestations in fish culture have been presented in table 2. These included Nuvan, Butox Vet, Cliner, Ectodel (2.8%), Emamectin Benzoate (EB), Hitek Powder, Paracure-IV etc. Among these Butox Vet and Cliner has comparatively higher market demand than other products. However, there has been no official recommendation for use of such products in aquaculture, although many such products have been permitted for use in animal medicine and agriculture as insecticides. In European countries, the anti parasitic drugs that are mostly used to control the sea lice contain Dichlorvos, Azamethiphos, Hydrogen peroxide, Ivermectin, Emamectin, Cypermethrin, Deltamethrin, Teflubenzuron, and Diflubenzuron as the active ingredients [15]. Although a number of products appear to be available to veterinarians and salmon farmers in European countries only a few are prescribed. Only Emamectin Benzoate (EB), has been used as medicated feed in all jurisdictions. In fact, EB is the only product used in Canada (under Emergency Drug Release) and the US (INAD) for control of parasitic infestations in fish [13].

A wide range of chemicals are available for use in aquaculture as disinfectant and as a measure of better health management. The comprehensive range of antimicrobial disinfectants or sanitizers with their active ingredients, commonly marketed for fish health management have been presented in table 3. Some of the commonly used chemical preparations were Virgo, Germicida, Ecodyne, Viranil, Mizuphor, Bionex-80, Sokrena-WS, methylene blue, formalin, hydrogen peroxide, potassium permanganate, copper sulphate, malachite green etc. Besides these, Bleaching powder, Aquakleen, Bkc Plus (Benzalkonium chloride), Novir, Polydard+, Formalin, etc. were by fish farmers for disease treatment. Formalin is also used to control protozoan parasite infestation and BKC is used for controlling bacterial disease (Table 3). Formalin, has been approved by the US FDA for use in aquaculture. However, when applied to ponds, it can kill phytoplankton and cause oxygen depletion. Formalin apparently reacts with ammonia to form hexamethylene-triamine and possibly formamide, a toxic substance to aquatic ecosystem [33]. Other researchers have also reported use of such chemicals in pond culture and in hatchery operations [14,18]. Sharker et al., [24] reported use of Efinol for stress management and a variety of disinfectants in different aquaculture operations in Bangladesh. These were mostly used in hatchery, grow-out systems and cleaning of for equipment and materials to maintain hygiene and to control pathogen load [12], as also observed in the present survey.

Furthermore, it was observed that farmers frequently use various combinations of microbial preparations as feed-probiotics and water remediation, for regular maintenance of fish health and pond environment (Table 4). Some of the probiotics used in feed included Y-Max, Novib, Lactoplus, Biovet-Yc, Yea Sacc, Gold Yeast and Saccharolact and some water probiotics included Bio-Trim, Thiomax, Optibact, B4, Terragard-SP, Uni-Proclean, EcoTech, Optima, Eco Taxnil, Sludg Nil, Bioclear etc. Probiotics are the preparations of microbial organisms and yeasts having beneficial effects in nutrient utilization, promoting digestion, growth and enhancement of immune response in the host body [34]. Gram positive spore forming *Bacillus spp*. is the major constituents in most of the commonly used probiotics in fish farming [35]. Some research trials have indicated immuno-stimulatory effect of probiotics in several species of freshwater fish [8,36]. Use of probiotics as eco-friendly substitute to antibiotics and other drugs, have found common application in disease management in aquaculture. Probiotic formulations contained wide range of beneficial bacterial strains including *Bacillus sp., Lactobacillus sp., Nitrosomonas sp., Aspergillus sp., Pseudomonas sp., Clostridium sp., Rhodococcus sp*., *Rhodobacter sp*. and *Saccharomyces cerevisiae.* Although a wide range of products containing different combinations of above probiotic organisms in different combinations were marketed in high demand, the authenticity and quality of such products could not be verified. A significant observation made was that the use of such

probiotic products have significantly increased in last few years, mostly in shrimp culture practices and their application in grow-out carp culture is also increasing. Many such products were manufactured locally, packed and sold with attractive packages, most of the products did not mention the types and quantity of organisms contained in such products. However, such products were in high demand in all aquaculture zones, indicating their effectiveness, although the utility of such products have not been scientifically proved.

In aquaculture, feed is one of the important component and constitutes approximately 50-60% of total cost of aquaculture production. Accordingly, farmers use a range of feed supplements along with farm made or floating feed for wellbeing of farmed animals. Growth promoters are the compounds chemical or biological substances supplemented in fish feed for fattening, effective utilization of feed, providing better immunity, regulating the intestinal micro flora and increasing the vitality of fish [37]. Several such substances/products were found in use to enhance the growth rate of fish in India. Among these different feed supplements containing essential micro and macro minerals, vitamins, proteins or amino acids were frequently used as growth promoters. There are 10 essential amino acids in fish species viz. arginine, methionine, histidine, leucine, isoleucine, lysine, tryptophan, phenylalanine, threonine, and valine.

Trade Names	Active Ingredients	Dose and Dosage
Addoxy	Tetraacetyl ethylene diamine, Sodium perborate, Adsorbants and De-odorizers	500 g/ha
ALTIMATE-ZM AQUA	Hydrated sodium calcium alumino silicates, Buffered organic acids, activated charcoal and Dried neem leaf powder	10 k/acre of water spread area
Aqualite	Zeolite	25-30 k/acre
Clarity	Edetic acid, Hydrated alkaline sulphate, Peroxides, Amitoxins, Alluminium dehydrated silicates	1-2 k/acre
Clinzex-DS	Aquaculture grade Zeolite	Pond: 50 k/Ha, During culture: 15-20 kg per Ha
Earth	Humic acid, Humin cytokynine, Auxine, Fuxine, Fulvic acid	1 l/acre
Enrich	Ca, P, Fe, Zn Mg, Cu Co, Cr, Bo, Al as chelating salts	1 pack (2 k)/acre
Halonex	3 methyl,4 Alkyl two chain Brominated halogen Compound-6%w/w, Potentiser, Buffers, Stabilizers, Emulsifiers	Prawn and shrimp: 5 l/acre Fish: 500 ml-1 l/acre
Jinong Humic Acid	Active humic acid, Nitrogen, Phosphorus, Potassium, Molybdenum Manganese, Iron, Zinc, Boron, Copper	1 l/acre
MPC	Extra pure $MgCl_2.6H_2O$, Potassium chloride and Sodium chloride fused	4-5 k/acre
Nutrisoft	EDTA concentrated aluminium dehydrated silicate stabilizers of ammonia, Fe hardness toxin binders and ammonia reducing agents	1 k/acre
Toxi Clean Aqua	SiO_2-51%, Al_2O_3-32%, Fe_2O_3-3%, Na_2O-3%, MgO-2%	10-20 k/acre of water
Ammo Curb	Extract of the plant *Yucca schidigera* and fortified with nitrifying bacteria (probiotic)	300-500 g/acre every 10 days when ammonia level increases
Ammo Trap	Minimum 10% of glyco components from *Yucca schidigera* concentrated extract	1 l/Ha every 2 weeks for ammonia removal
Ammo-Nil+	Salts of alkyl sulfonic acids with saponins	500 g/acre
BioCURB®Dry	Natural extract of plant *Yucca schidigera*, Ammonia binding agent and flavouring agent	1 k/Ha, thoroughly mixing with sand and sprinkling water
De-Odorase	Ammonia reducer (*Yucca schidigera* extract)	250-300 ml/Ha
De-odr	*Yucca schidigera* and reducing agents with stabilizers	Shrimp ponds: 500 ml/acre Fish Ponds: 200 ml/Ha/1m water depth
Gardian	*Yucca Schidigera* plant extracts in suitable stabilizers and potentiators	200-300 ml/Ha in shrimp/Fish farm
Mex Yucca	100% natural pure *Yucca schidigera*	250-300 ml/acre for 1 m water
Odoban-A30	*Yucca schidigera* steroidalsaponins, Urease inhibitors with stabilizers and fillers	Pond preparation: 500 g/Ha, Food application: 1 g/k
Odocure	Spray dried *Yucca schidigera* extract powder with stabilizer	500 g/acre (3 ft depth, @ 15 days interval)
Sulphanil-H	*Thiobacillus*, *Chlorobium*, Disulfovibriodisulphuric acid	1 k/Ha for every month
Toxi-Clean Aqua	HSCAS (Zeolite) withYUCCA extract	Pond preparation: 50 k/acre For regular use: 10-20 k/acre
ModuloxTMTab	Sodium perborate and zeolite (catalyst) to improve oxygen level in aquatic pond	• If oxygen level is upto 3 ppm, use 1 k/Ha • If oxygen level is lower than 3 ppm, then use 3-5 k/Ha
O_2 Marine	Long acting oxygen releasing tablets (Sodium perborate)	1 kg/Ha at low oxygen level
O_2 Max	Fast acting oxygen releasing tablets for aqua culture ponds	Low oxygen level: 1 kg per hectare of pond, O_2 deficiency: 3-5 k per hectare of pond
Oxycal	Calcuim peroxide with stabilizers	2-3 k/acre
Oxy-Gen	100% disposable peroxide of Ca	1 k/Ha
Sodium percarbonate tab	$Na_2Co_3.1.5H_2O$ (MW 157.01)	500 g/Ha or 4 oz in a gallon of warm or hot water
Toximar	Mixture of natural zeolites for use in aquatic feed	For pond preparation: 40-50 k/acre, For culture pond usage: 10-20 k/acre

Table 1: Chemicals and their formulations available for water quality maintenance in aquaculture.

Trade Names	Active Ingredients	Dose and Dosage
Bancoxy-K	Amprolium hydrochloride 20% w/w, Menodione sodium bisulphite (0.2%)	30 g in 25-30 litres of drinking water
Paramed	Pentapropyl methyl-thio-benzimidazole carbamate 5%	1-1.2 k/ton feed for 3 Days
Nuvan	Dichlorvus tech. 83.0%, Xylene 8.0%, Epichlorohydrin 1.0%, Emulsifier 7.0%, Triethanonline 0.9%, Methylene Blue 0.1%	150 to 250 ml per acre
Decis	Deltamethrin 2.8% (W/W), Triglyceride, Stabilizer-Butylated hydroxyl toluene-1%	100 ml/acre
Hilmala	Malathion tech. 52.8% w/w, Stabilizer (Epichlorhydrin) -1% w/w, Emulsifier (Alkyl aryle sulphonate and polyoxy ethelene ether-5%, Aromex -41.2% w/w	Apply @ 0.05%
Starchlor	Dichlorovus-76% E.C.	150-400 ml/acre of crop field
Nivaard	Azadiractin 0.15%, (1500 PPM) Min	1 l/acre
ButoxVet	(Deltamethrin 1.25%)	20-30 ml/acre
Clinar	Cypermethrin	20-30 ml/acre meter of water
Ecto Del 2.8%	Deltamethrin E.C 2.8%	50-100 ml/acre pond 5 feet depth
Hitek powder	Ivermectin IP 1% w/w	Mix 200-250 of Powder with 1 ton of feed before feeding
Copper (II) Sulfate pentahydrate pure	Copper sulphate	1:2000 with water/acre
BROFIN™ 5%	Bromine 5% w/v	5 l/Ha
Paracure – I.V	Ivermectin: 2% w/w	250 gm per ton of feed for 4 days
Dichlorvos-E.C. 76%	Dichlorvos-76%	150-250 ml/acre
Blue Caloxy	Calcium peroxide 75%	1 kg per ton of feed or 1-2 kg/0.1 Ha

Table 2: Antiparasitic drugs, chemicals and formulations commonly used in aquaculture.

Trade Names	Active Ingredients	Dose and Dosage
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
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
Ecodyne	Polyvinyl pyrolidone iodine complex with 20% activity, Stabilizers, Emusifiers	250-350 ml/acre foot of pond water
Viranil	Potassium monopersulfate, Potassium sulphate, Potassium hydrogen sulphate, Color : Tartrazine	5-10 g/ton of water in hatchery1-2 k/acre of pond
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
Wgd Care	Extract of *B. subtills, L. planatarum, Streptomyces rimosus*, 1-Cyclopropyl-6-fluoro-1,4-dihydro-4-oxo-7, (1-piperazinyl)-3-quinolinecarboxylic acid, Chemical adjuvants, Herbal Synergisers, Mineral components	In Feed: Preventive: 2 ml/10 kg once in 15 days Curative: 1 ml/kg one day In pond water: Preventive: 100 ml/acre once in 15 days Curative: 400 ml/acre one day
Mizuphor	Alkyl aryl polyoxyethylene iodine complex which provides essential plus 10% iodine along with buffering and emulsifying agent	Shrimp/prawn pond: 2-3 l/Ha (1m water depth)
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
Bactovirnil	• Potassium monopersulphate • Sodium dodecyl benzene sulphonate • Malic acid	2 kg/Ha during culture period, twice in a month Hatchery: 5 ppm for reservoir water in Tanks: 1 ppm, repeat every 4 days
Sokrena-Ws	Didecyledimethyle ammonium chloride	5-10 l/Ha pond at 1 mt depth or @ 0.5-1 ppm (i.e., 0.5-1 ml in 1000 l)
Potassium permanganate	Potassium permanganate	20 g/10l water and spray or dip treat
Benzalkonium chloride (50%)	Benzalkonium chloride-50%	0.5 ppm
Blesson	Benzalkonium chloride	Ponds: 2-4 l/Ha, 1 m water depth)
Broot 5X (Bromine)	Tetradecyletrimethyle ammonium bromide, Alkylbenzyledimethyle ammonium chloride, Nonyle phenol ethoxylate	1 l/acre (For juveniles till 8-10 g size) 2 l/acre (above 10 gm size)
Malachite green (M.S)	Malachite Green	Dip: 66.7-100 mg/l, Bath: 6.7 mg/l
Protect	Alkyl dimethyl benzal ammonium chloride 50% w/v	500 ml/acre foot of water
Steridol p.f.	Nonyle alkyl phenoxy choline, Ethelene oxide iodine complex (providing 2% I2)	Hatcheries: 20 ml/l water (2%) Prawn tank: 500 ml/acre Fish tank: 1 l/acre
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

Biolin plus	Each 100 gm contains: Formaldehyde solution I.P -7.5 ml Strong glutaraldehyde solution B.P-7.5 ml Benzalkonium chloride solution I.P-5.0 ml	5 l/Ha in 1 metre water depth
Bkc plus	Dimethyl Benzyle ammonium chloride-50%	1 l/acre
Novir	Triple salt containing: Potassium- peroxomonosulphate, Sodiumdodecyle-benzenesulphate, Sulphamic acid	500-750 g/acre once in 15 days
Polgard+	3 methyl, 4 alkyl 2 chain brominated halogen compound, Buffers and Stabilisers and Emulsifier	1 l/acre feet level of pond water
Glyphogan	Glyphosate 41% SL	2-3 l/Ha

Table 3: Available antimicrobial or disinfectants used in aquaculture practices.

Trade Names	Active Ingredients	Dose and Dosage
Y-Max	*Saccharomyces cerevisiae,* *Saccharomyces boulardil*	5 g/k feed
Novib	*Bacillus amyloliquefaciens*-3.5 × 10^6 *B. cereus*-12.5 × 10^6 Excipients: q.s	2-3 k/Ha based on the degree of vibrio infection or 10 g/kg feed if given through feed
Lacto plus	Each kg Contains: Lactobacillus (60,000 million CFU Yeast culture, Betaine amylases, Proteases, Lipases B-Complex and Minerals	Shrimp: 5-8 g/k feed Fish: 3-5 g/k feed
Biovet-Yc	*Saccharomyces boulardii*-30,000 million *Lactobacillus acidophilus*-45000 million *Saccharomyces ceraevisiae*-300000 million CFU, Alpha amylase-5 g, Sea weed powder-100 g	1.5 k/ton feed
Yea Sacc	Live yeast culture (*Saccharomyces cerevisiae* strain)- 10%	100 g/ton feed
Saccharolact	*Lactobacillus acidophilus, L. casei* *L. buulgaricus, Streptococcus lactis* *Bacillus subtillis, Saccharomyces cereviseae* varieties-10^{12} CFU/g	50 g/m feed mass/as directed by the nutritionist
Bio-Trim	*Bacillus sp*- 10^7 CFU/g	2-3 k/Ha
Actisaf$^{Sc\ 47}$	*Saccharomyces cerevisiae*	3 g to 10 g/animal/day
Gold Yeast	*Saccharomyces cerevisiae*	500 g/ton of feed in all complete rations
Thiomax	*Bacillus subtillis, B. lichenformis, B. polymyxa, B. megaterium, B. pumilus, B. spec* (TF2), *Nitrosomonas, Nitrobactor, Thiobacillus spp.* and micronutrients	Prawn and Shrimp: 2-3 k/acre
Optibact	*Bacillus sutilis, circulans, megatherium, polymixa*-4.5 × 10^{10} CFU/g, *Thiobacilus, thiooxidans*, *Denitrifians*- 4 × 10^{10} CFU/g, *Nitrosomans* and *Nitrobactor*- 4 × 10^{10} CFU/g, *Rhodococcus* and *Rhodobacter* – 4.5 × 10^{10} CFU/g	300-400 g/acre
B4	Bacillus species (>5 × 10^{10} CFU/g) working in all kinds of aquaculture systems in all salinities and temperatures	Pond water: 200 g/acre/week Feeding: 2 g/k feed
Pond Dtox	H_2S Oxidising bacteria (*Paracoccus pantotrophus*)-3.1 × 10^9 CFU/g	Culture: 1 k/10000 m^2 If water becomes Black with bad odour: 1st Application- 2 k/10000 m^2 and 2nd application after 3-4 days-(1 k/10000m^2)
Terra Gard-SP	Soil probiocs in *Thiobacillus* and *Bacillus* species in the natural carrier with adjuvants	1-2 k/acre
Uni-Proclean	*Bacillus subtilis, B. licheniformis, B. megatherium, B. Polymixa, B. firmis, B. mesentricus, Cellulomonascartae, Pediococcus , Aspergillusoryzae, Perococcusdenitrifican*	500 g/Ha NLT 20 billion CFU/g
Super Biotic	*Bacillus spp.* 10^7 CFU/g	3-5 k/Ha/week
Clean Bot	*Aspergillus awamori, Daedaleaflavidaa, Trichoderma reesei, Cellulomonas spp, Pseudomonas spp*	500 g/acre every 15 days
Eco Tech	*Bacillus subtillis*- 5 × 1010 CFU/g, *B. licheniforms*-3 × 10^{10}CFU/g, *B. meghatherium*-6 × 10^{10} CFU/g, *B. Thiobacillusthioxidin*-109 CFU/g, *B. Nitrobactor*, *Nitrosomonas*-10^7 CFU/g, *Rhodococus*-1 × 1011 CFU/g	200-250 g/acre
Optima	Contains high density CFU of *Bacillus subtills, Bacillus licheniformis, Bacillus megaterium, Bacillus polyxa ,Bacillus pumilus, Lactobacillus sporogenies*, and denitrifying *bacteria*	1 k/Ha
PH Fixer	*Bacillus species* 10^8 CFU/g, Microbial media and buffer mixes	4 k/Ha thrice
Eco Toxnil	*Bacillus sp.* (5 × 10^9 CFU/g)-5.0 g *Bacillus thermodenitrificans* (5 × 10^9 CFU/g)-9.0 g	400 g/acre
Sludg Nil	Strains of *Rhodococcus sp., Rhodobacter sp., Bacillus sp., Cellulomona sp., Aspergillus sp., and Pseudomonas sp*	Culture ponds: 12-24 cakes/acre
Bio Clear	Zeolite containing *Bacillus sp., Nitrobacter sp., Cellulomonas sp.* and *Acetobacter*	Pond: 5 k/acre, once every fortnight
Biofloc	High density water and soil probiotic specially designed for aquaculture (12 billion CFU/g)	Fish ponds: 100-200 g/acre Hatchery: 30-50 g/10 ton of water
Toxoff	Combination of stabilized and lyophilized probiotics like *B. subtilis, Lactobacillus lacyis* and *Thiobacillus versutus*	1 k/Ha
Nitrocare-Lq	*Yucca schidigera, Aloevera, Bacillus subtillus, Bacillus polymyxin, Bacillus linchcniformis, Nitrosomonas, Nitrobacter, Pseudomonas*	1 k per hectare-Mix with pond water and apply uniformly
Pond Fresh	*Bacillus subtilis, B. licheniformis, B. Pumilus, Lactobacillus lactis* and *Rhodobacter*	3-5 k/acre or as directed by Aqua culturist
Bio Balance=C:N	*Bacillus subtillis, Lactobacilus pentoues, Arthrobactor, Rhodococcus, Nitrosomonas Nitrobactor, Thiobacillus, Bacillus liquifaecious*	2 l/acre

Cura Mid	*Nitrosomonas sp, Nitrobacter sp, Bacillus sp, Aerobacter sp, Cellulomonas sp.* Fortified with bio-active compounds	12-24 cakes/acre based on Days of Culture (DOC) or as advised by aquaculture consultant
Thiopro-Ds	Most potent soil probiotic containing Three species of *Thiobacillus sp, Nitrosomonas, Nitrobactor*	250 g/acre

Table 4: Probiotics (Feed/soil/water) commonly used in aquaculture practices.

Among these, the limiting amino acids are mainly lysine and methionine which should either be supplemented through the feed or provided from the aquaculture environment [38]. A wide range of feed supplements which are commonly used by fish farmers and hatchery operators in India, included Frankzole, Liv52 Protec, MV24, Star Shrimp, Kalvimin Gold, K-Max, Survivor, Calmag, EnvoMin, Agrimin, Super food etc., (Table 5). Whereas most of the products are imported and locally mixed, there are number of feed-mills located in Andhra Pradesh, which manufacture feed for fish and shrimp culture. Use of farm made feed is also gaining importance. A significant observation in the survey was many farmers especially in commercial grow-out cultures, were not using commercial-grade feed but purely relying on locally available rice bran or Deoiled Rice Bran (DORB) mixed with limited quantity of oil cakes (5-10%) with or without vitamin and mineral mixtures. Sharker et al., [24] reported use of different growth promoter in Bangladesh aquaculture, to enhance fish production which included Megavit Aqua, Aqua Boost, Aqua Savor, Vitamin premix, Fibosoel, Grow fast, Orgavit auqa, AQ-Cell, AQ Grow-G, Fish vita plus, AQ Grow-L, Nature Aqua GP, Vitamix, F Aqua, AC mix and many more [20].

Antibiotics with different trade names were seen in the market and used by the farmers in disease management as preventive and control methods, the list of which has been shown in table 6. These included Oxymycin, Enrox, Hydrodox, Lixen Oxytetracycline, Hostacyline Vet, Cifintas AQ etc. These antibiotics were used for treating the bacterial 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 ictaluristrains*. It has been shown that antibacterial are the main course in juvenile or larval stages of aquatic animal production as prophylactic agents [25,29,39]. Among antibiotics, oxytetracycline has been the most widely used antibiotics in aquaculture practices [19,40]. Chowdhury et al., [14] reported that the antibiotics like Renamycin (Oxytetracycline) had significantly controlled the bacterial infection when used at a dose rate of 50 mg/kg body wt/day for 3-5 days with 80-90% efficacy. Rao et al., [41] indicated Oxytetracycline, Sulfadiazine and Trimethoprim combination was the most popular chemotherapeutants in freshwater aquaculture and hatchery systems in India, although their present use has been limited because of lowered efficacy. At therapeutic levels antibiotics are often administered for short periods in feed to groups of fish that share common tanks or cages.

Besides food-fish production, aqua-drugs, chemicals and antibiotics have got large scale application in ornamental fisheries. In recent years, the increased development of ornamental fish culture in many states, has opened up problems of disease and water quality deteriorations in ornamental fishes. Ornamental fishery is becoming a billion dollar industry in India having great export potential. Disease causing factors in aquarium or ornamental-fish ponds are mostly due to poor food, rapid fluctuation in water temperature, lack of oxygen or some other adverse conditions [30]. The details of anti-parasitic, anti-fungal and antibiotics etc., used in ornamental fisheries have been presented table 7 and 8. Most of ornamental fish varieties are normally procured from neighbouring Asian counties to India mainly through legal and illegal means. Ornamental fisheries have been the source of exotic bacterial and viral pathogens that has mandated strict quarantine regulations. Occurrence of viral diseases like Cyprinid Herpesvius-2 (CyHV-2), Koi Rana Virus (KIRV), Carp Edema Virus (CEV), Megalocytiviris and Goldfish haematopoietic virus necrosis herpes have recently been reported in ornamental fish culture [42]. In addition, koi sleepy disease caused by CEV was reported in *Cyprinus carpio* [43]. Because of the fact that there are no strict guidelines in ornamental fisheries, a wide range of chemicals, antimicrobial agents, insecticides and antibiotics, are being used by farmers and ornamental fish operators to control disease problems.

In the present study, data on 364 aqua-drugs and chemicals were collected, 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%) (Figure 1). This is in contrast to aqua-drug use pattern during 1994-1998, when antimicrobials (antiseptics, sanitizers and antibiotics) constituted more than 50% of total products (based on our previous survey, unpublished data), which were mainly used in newly developing shrimp aquaculture in coastal Indian States [44]. Decline in tiger shrimp *Penaeus monodon* culture led to development of improved methods of carp culture, thus leading to enhanced application drugs and chemicals in carp culture. Furthermore, variation in usage pattern of aqua-medicines, drugs and chemicals were observed in different states like in Andhra Pradesh (Figure 2), Chhattisgarh (Figure 3), Jharkhand (Figure 4) and in Odisha (Figure 5), which was dependant on culture practices revalent in respective regions. A significant observation, was that probiotics constituted maximum (31%) products in Andhra Pradesh followed by 28% feed supplements and only 2% of products belonged to antibiotics category (Figure 2). This indicated that fish farmers in Andhra Pradesh, being considered innovative and economically advanced, were relying more on probiotic products than on antibiotics, specifically in shrimp (*Penaeus vennamei*) culture. Again, marketing and use of antibiotics could not be observed in Chhattisgarh, although use of antiseptics/ sanitizers and probiotics were noted (Figure 3). Maximum aqua-products (50%) belonged to feed supplement category (Figure 3). The usage pattern was almost similar both in Jharkhand and Odisha, although more number of antiseptics and sanitizers were used in Jharkhand, may be due to their application in cage culture (Figure 4). In Odisha, the usage pattern of aqua-medicines, drugs and chemicals has shown increasing trend in last few years (Figure 5), mainly due to rapid development of carp and shrimp culture in the state.

Trade Names	Active Ingredients	Dose and Dosage
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
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 (above 11week age)
MV24	Highly Bio available Vitamins (A, D3, E, K3, C, B1, B2, B5, B6, B7, B8, B9, B12 & Choline), Minerals (Calcium, Phosphorus, Cobalt, Copper, Manganese, Zinc, Potassium, Iodine), Amino acids (DL-Methionine and L-Lysine)	Fish-2 to 3 g per kg of feed Prawn-2 to 5 g per kg of feed
Lipidex	Lipids and Amino acids, Vitamin A, C, E, B12, Liver oil	20 ml/k of feed
Intramin-Ol	Nitrogen: 3.000 mg/ml; Phosphorus: 2.05 mg/ml Calcium: 30 mg/ml, Zn: 210 mg/ml, Fe: 110 mg/ml, Mg: 1100 mg/ml, Cu: 98-120 mg/ml Aqueous media: Q.S.	5-10 ml/k of feed
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
Venribee-Plus	Vit B-Complex with Vit-E	20-2 g/100 k fed
Kalvimin Gold	Each kg contains Ca-260 g, P-130 g, Mg-6 g, Mn-1.5 g, Fe-1.5 g, I2-325 g, Cu-4.2 g, Cn-9.6 g, Co-150 mg, S-7.2 g, K=100 mg, Na-5.9 mg, Se-10 mg, Vit-A=700000 IU, Vit-D3=70000 IU, Vit-E=250 mg, Nicotinamide-1g, Biotin-550 mcg, *Lactobacillus sporogenies*=15×10^{10} CFU	1 k per 100 k of feed
Grovit-C	Each gram contains vitamin-C 500 mg stabilizers anti oxidants and proper base	1 to 1.5 g/kg feed
Survivor	Mixture of short and medium chain monoglycerides and organic acids : Monocaprin, Monocaprilin, Monolaurin, Monobutyrin	7-8 ml/k feed in minimum of 2 meals/day
Antacid	Organic acids, Antioxidants, Organic selenium, Mannan, Oligosaccharides with *Alium sativum*	5-10 g/k feed
K-Max	Enriched Potassium, Chloride and other nutrients	During culture-10 to 20 k/ha/week
Novumin	Mineral concentration in 1 kg Organic Zn 40 g (4 %), Organic Cu 20 g (2 %), Organic Mn 40 g (4%), Organic Se 0.3 g (.03%), Guaranteed methionine activity - 54 g (54 %)	Farm: 5-10 g/k of feed, Hatcheries: 1-2 g/k of feed
Calmag	Mg^{2+}, Ca^{2+}, $SO4^{2-}$ and other minerals	40 to 60 k/Ha/week
Envo Min	Complex mixture of essential micronutrients in inert from 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
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
Aqua Vit-C	Bio available coated Vitamin-C	Shrimp: 1.0 g/k feed
Hydrovit C2	Each gram contains: Vitamin-C-350 mg, Hepato pancreatic stimulants-100 mg, Growth promoting factors-250 mg	Shrimp: 10 g/k feed Fish: 5 g/k feed
Agrmin 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
Agrimin	Co-150 mg, Cu-1200 mg, I2-325 mg, Fe-5000 mg, Mg-6000 mg, Mn-1500 mg, K-100 mg, Na-5.9 mg, S-0.922%, Zn-9600 mg, DL-Methionine-1920 mg	1-2 k mixed in 100 k feed
Him-C	Methyl paraben sodium, Propyl paraben sodium	For Fish/Prawn: 5-10 g/k of Feed
Kalvimin Forte	Vit A, D2, D3, E, B12, Ca, Cal-pantothenate and Ca, P, Mn, I2, Fe, Zn, Cu and antioxidants	2.5 k/ton of feed
Super Food	Zinc, Magnesium, Boron, Manganese, Molybdenum, Calcium, Potassium etc.	1 l/acre water depth 4ft
Jinong Sea Weed	Seaweed oligosaccharide, Mannitol, Nitrogen, Phosphorus, Potash, Alginate acid, Amino acid and Minerals	1.5 kg-2.5 kg per acre of pond water
Osmin	Ca=30%, P=9%, Mg=0.12%, Fe-0.6%, I2=0.1%, Cu=0.02%, Cloride=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

Table 5: Feed supplements or growth promoter used in aquaculture practices.

Trade Names	Active Ingredients	Dose and Dosage
Oxymycin	Oxytetracycline HCL IP	Fish - 100 g/200 k of feed for 5-7 days, Prawns - 2-4 g/k feed for 5-7 days
Enrox	Fluoroqunolone	Prevention : 5 g/k feed for 7 days, Disease-10 g/k feed continuously for 3 days
Lixen Powder	Each g contains Anhydrous Cephalexin: 75 mg	35-50 mg per k Biomass
Hydrodox	Doxycycline: 100 mg, Ascorbic acid: 80 mg	100 g/ton biomass
Oxytetracycline soluble powder I.P (Vet.)	Each 4 g contains: OTC-200 mg	3.5-7 g/100 Pound biomass
Cefintas Aq	Cephalexin - 7.5% w/w	7.5-10 mg/k body weight orally

Table 6: Antibiotics commonly used in aquaculture practices.

Agent	Dosage and Route	Parasites/Pathogens
A. Anti-parasitic agents		
Acetic acid, Glacial	2 ml/l × 30-40 s bath	Trematode, Crustacean ectoparasites
Chloramine-T	Prolonged bath 10-15 mg/l, repeat after 48 h	Protozoal and some Monogenean infections
Copper sulphate	100 mg/l for 1-5 min bath. Maintain free copper iron levels at 0.15-0.2 mg/l as permanent bath	Marine fish ectoparasites
Diflubenzuron (Dimilin ®)	0.01 mg/l permanent bath for 6 days × 3 treatments	Crustacean ectoparasites
Fenbendazole	2 mg/l permanent bath 7 days × 3 treatments, 50 mg/k orally, in feed 50 mg/k orally, in feed	Non-encysted intestinal nematodes
Formalin (37% Formaldehyde)	0.125-0.25 ml/l up to 60 min bath 0.015-0.025 ml/ permanent bath × 2-3 days	Ectoparasites
Ivermectin	0.1-0.2 mg/k i.m.	*Lernaea*
Leteux- Meyer Mixture	Stock solution (Malachite green 3.3 g/l Formalin) Use 0.015 ml/l bath × 3treatments	Protozoal ectoparasites
Levamisole	1-2 mg/l × 24 h bath	Internal nematodes
Malachite green	50-60 mg/l × 10-30 s bath; 0.1 mg/l permanent bath for 3days 100 mg/l topical to skin lesions	Protozoal infection in fresh water fish
Mebendazole	1 mg/l × 24 h bath	Monogenean trematodes
Mebendazole + Closantel	(Use Mebendazole 75 mg/l + Closantel 50 mg/l e.g., Supaverm®) 1ml/400 l × 1	Monogenean trematodes
Metronidazole	25 mg/l permanent bath for 48 h × 3 treatments 100 mg/k in feed × 3 days	Internal flagellates (e.g., *Hexamita Spironucleus*)
Piperazine	10 mg/k in feed × 3days	Non-encysted intestinal nematodes
Potassium permanganate	100 mg/l × 5-10 min bath 2 mg/l permanent bath	Fresh water protozoal and Crustacean ectoparasites
Praziquantel	2-10 mg/l up to 4 h bath × 3 treatments; 5-12 g/k feed for 5days	Monogenean trematodes ectoparasites, Cestodes
Salt (Sodium chloride)	1-5 g/l permanent bath 30-35 g/l × 4-5 min bath	Fresh water protozoal ectoparasites
Toltrazuril	30 mg/l × 60 min × 3 treatment	Myxozoans
Trichlorphon	0.5 mg/l permanent bath or 0.5-1.0 mg/l permanent bath × 10 days	Crustacean ectoparasites
B. Antifungal agents:		
Formalin (37% formaldehyde)	1-2 ml/l bath, up to 15 min 0.23 ml/l bath, up to 60 min	Mycotic infections on eggs (do not treat within 24 h of hatching
Itraconazole	1-10 mg/k daily in feed for 1-7 days	Systemic mycoses
Malachite green	1-2 mg/l × 30-60 min bath 0.1 mg/l permanent bath, 1% topical to skin lesions	Mycotic infections in fresh water fish

Table 7: Anti-parasitic and anti-fungal agents used in ornamental fish diseases.

Agent	Dosage and route	Indications
Acriflavine	500 mg/l × 30 min bath 5-10 mg/l prolonged bath	Skin bacterial infections
Amoxycillin	40-80 mg/k in feed for 10 days	
Chloramine -T	15.0-20 mg/l for prolonged bath, repeat after 48 h if necessary	Treatment of bacterial gill disease, Fin rot
Enrofloxacin	2.5-5.0 mg/l × 5 h bath 5-10 mg/k orally for 10-15 days	Skin bacterial infections, Red disease, Ulcers
Erythromycin	100 mg/k orally, in feed × 10day	Generalized bacterial infection
Kanamycin	50-100 mg/l × 5 h bath 50 mg/k in feed for 14 days	Generalized bacterial infection
Methylene blue	2 mg/l prolonged bath	Treatment of bacterial gill disease, Fin rot
Nifurpiriniol (Furanace®)	1-2 mg/l × 30 min to 6 h bath 0.1 mg/l Prolonged bath 4-10 mg/k in feed for 5 days	Generalized bacterial infection
Nitrofurazone	100 mg/l × 30 min bath 2-5 mg/l prolonged bath for 5-10 days	Generalized bacterial infection
Oxytetracycline	10-100 mg/l × 1 h bath 55-83 mg/l in feed × 10 days	Generalized infections
Potassium permanganate	5 mg/l × 30-60 min bath 2 mg/l permanent bath	Broad spectrum anti-septic
Povidone-iodine	Topical application to wounds	Broad spectrum activity
Sulphadimethoxine and Ormetoprim (Romet®)	50 mg/k in feed × 5 days	Broad spectrum activity

Sulphadizine and Trimethoprim (Aquatrim)	20 mg/l × 5-12 h bath 30 mg/k in feed × 7- 10 days	Broad spectrum activity
Sulphadoxine and Trimethoprim	75 mg/k i.m × 8-12 days	Broad spectrum activity

Table 8: Antibacterial agents used in ornamental fish disease.

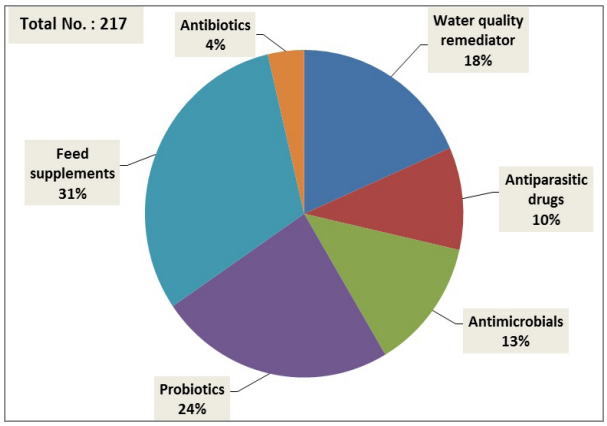

Figure 1: Drugs, chemicals or formulations used by farmers in Indian aquaculture.

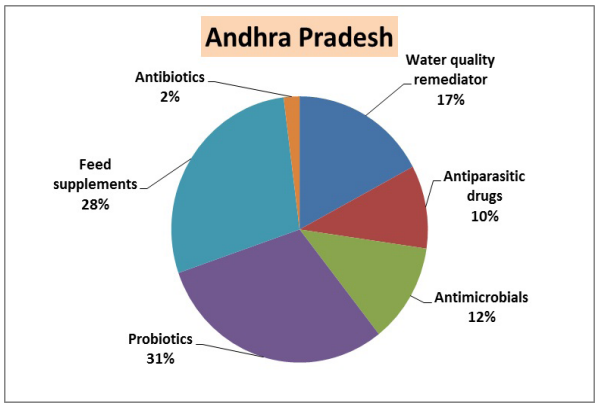

Figure 2: Drugs, chemicals or formulations used by farmers in selected districts of Andhra Pradesh.

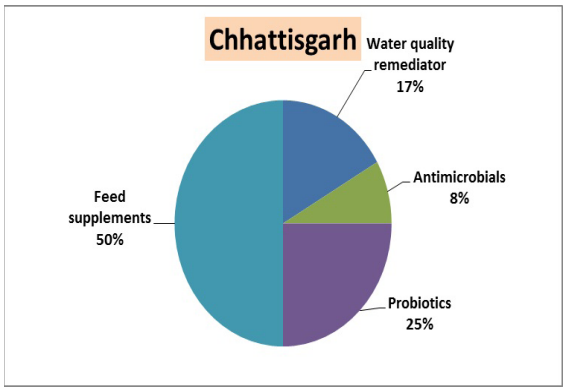

Figure 3: Drugs, chemicals or formulations used by farmers in selected districts of Chhattisgarh.

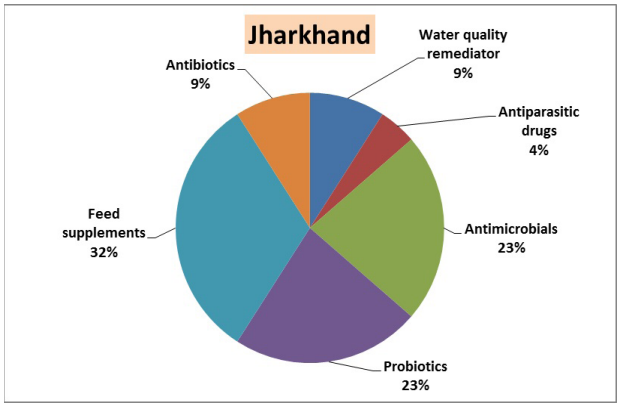

Figure 4: Drugs, chemicals or formulations used by farmers in selected districts of Jharkhand.

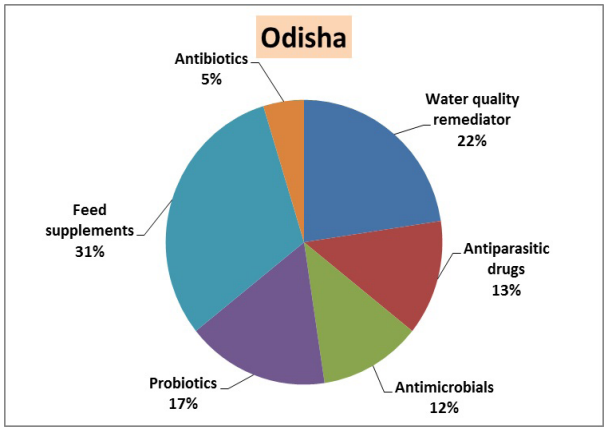

Figure 5: Drugs, chemicals or formulations used by farmers in selected districts of Odisha.

Even though use of antibiotics and other antimicrobials in aquaculture practice is unwarranted, these are being used as both therapeutic and prophylactic purposes. Although at present there are no National Aquaculture and Fishery policy and no Aqua-drug control act/ regulation in vogue, some Indian States have regulation and fishery policy, discouraging application of such products in fisheries and aquaculture. However, such aqua-medicines, drugs and chemicals are being marketed in the name of "feed-additives", thus by passing existing regulations. Some manufactures are in practice of incorporating certain antibiotics in shrimp/ fish feed as a preservative, on the line that being used in animal feed production and marketing. Another significant observation in all concerned states was dependency of fish farmers on private aquaculture consultants or representatives of feed or chemical suppliers for time to time advice for better harvest of crop and disease management. Considering high investment in feed, the marginal farmers in the region were being persuaded by feed supplier

units to take the feed "on-loan basis" and make payment once the harvest of the product was over. The consultants also assure to take care of the cultured animals and the produce, by regular visiting to the remotely located fish/ shrimp farms from time to time. This method was found to be most suitable for small and marginal farmers which constitute more than 60% of total fish farmers. By this way the so called consultants persuade the farmers to purchase and apply various aqua-medicines, drugs and chemicals in the culture system to protect the crop against disease outbreaks. It was observed that most farmers in all aquaculture zones were not even aware of quality and indications of aqua-medicines and formulations they use in their farms and were fully dependent on such aquaculture consultants and work under their guidance. That may be the reason of booming of aqua-medicine sector in most aquaculture developing zones, leading to indiscriminate use of such products. Although use of such aqua-medicines is much less in Government fish/ shrimp farms nor State fishery department recommend use of such aqua-medicines, drugs and chemicals, their use is more in most private farms, mainly because of high stocking and intensive culture practices.

It has been reported that although antibiotics have no therapeutic value against viral diseases, still many farmers are in practice of using variety of antibiotics and other antimicrobials in culture systems to protect the crop against viral diseases [45]. Use of antimicrobials, particularly the antibiotics has been very much limited in most part of the world even at standard therapeutic dose [28]. Intensive fish and shrimp farming has promoted the growth and development of several bacterial infections, which has led to increased use of antimicrobials [20,46]. Sharker et al., [24] reported use of different antibiotic preparations like Renamycin, Bactitab, Chlorsteclin, Cotrim-Vet, Orgacycline-15%, Oxysentin 20% and Sulfatrim in Bangladesh aquaculture practices. In shrimp hatchery operation of "The Andhra Pradesh Shrimp Seed Production, Supply And Research Centre" (TASPARC) hatchery at Bheemunipatnam, Andhra Pradesh, three categories of chemicals viz. i) Nutrient chemicals for live feed culture, ii) Water treatment chemicals and disinfectants and iii) drugs and chemicals are being used as prophylactic and control measures, were commonly used [17]. Calcium chloride, Sodium thiosulphate, EDTA was used as water treatment chemicals. Formalin, Idophore, Potassium permanganate and dilute acids were used as disinfectants. Aquatic grade antibiotics like Chloramphenicol, Erythromycin, Oxytetracyclins, Furazolidone, Kanamycin, Neomycin and Antifungal drugs like Formalin, Treflan and Malachite green were used in shrimp hatchery operations [17]. Chowdhury et al., [19], observed commonly available antibiotics in Bangladesh aquaculture included Renamycin, Oxysentin 20%, Chlorsteclin Oxy-D Vet, Aquamycin, Orgamycin 15%, Orgacycline-15% etc. Major active ingredients of these antibiotics were Oxytetracycline, Chlorotetracycline, Amoxicillin, Doxycycline etc. They reported that nearly fifty two pharmaceutical companies were marketing around 300 products, most of which were imported from other countries like USA, Thailand, Malaysia, Belgium and China etc. They also indicated that some problems associated with indiscriminate the use of such chemicals in aquaculture was due to lack of knowledge of farmers about the use of chemicals, appropriate dose, method of application and their indiscriminate use of chemicals, similar to that observed in the present survey.

In the present survey, as reported by many farmers, use of aqua-medicines, drugs and formulations have led to enhanced fish and shrimp production leading to high economic gain. Although drug residue has been a cause of concern for export of shrimp and even led to several rejections of international consignments, causing serious loss and embarrassment to shrimp industry, presently there are no alternatives to use of antimicrobials for use in aquaculture. Again there has been no such regulation for internal consumption and marketing of fish/ shrimp. There are no commercial fish vaccines or scientifically proven immune stimulants in the market for protection against bacterial and viral diseases. Another encouraging observation made in some fish farms in the surveyed states was use of "Organic fish culture" and the farmers do not use any external chemicals and drugs in fish culture, although they use lime, super phosphate and urea in pond construction and water management. Some farmers use traditional methods of "fermented farm waste products" that included mixture of organic materials like cow dung, cow urine, molasses with some other materials, and used from time to time in pond water. As per their observation, use of such fermented product has led to enhanced plankton growth, less occurrence of fish bacterial and parasitic infestations. However, usefulness of such product has not been scientifically proved, although such practice of use of fermented waste products has been gaining popular in many fish farms.

FDA's Center for Veterinary Medicine has identified a number of "low regulatory priority aquaculture drugs". The list of these compounds and their indicated use and usage levels has been presented in table 9 and 10. These compounds have undergone review by the Food and Drug Administration and have been determined to be new animal drugs of low regulatory priority [47]. Gulations on use of various drugs/ chemicals/ antibiotics in aquaculture and some of the products which have application in human health have been banned for use in aquaculture. European Union, US FDA and Japan have notified zero level drug residues of selected antibiotic viz. Chloramphenicol, Furazolidine Nalidixic acid Neomycine Oxolinic acid (quinoline compound), Oxy tetracycline, Tetracycline and Sulphamethaxazole/ Trinethoprim (Sulphonamide) in the imported shrimp [45,48] Accordingly, on the basis of Government of India notification, MPEDA and Coastal Aquaculture Authority [49] have banned use of various drugs, chemicals, antibiotics and other formulations in aquaculture (Table 11). Although the list mentioned names of such products including antibiotics banned for use in aquaculture, it does not mean that the chemicals/ drugs/ antibiotics not mentioned in the list are permitted by the Government authority for use in aquaculture. Hence time has come that fish farmers and hatchery operators must be made aware of such list of drugs and chemicals approved for use in aquaculture, such as those specified by USFDA and regional guidelines may be developed on the basis of such international rules and guidelines.

Besides wide unregulated use of drugs and chemicals in aquaculture, reports have indicated that there are many other sources of antibiotics, drugs and chemicals accumulating in aquatic ecosystem [48] and the amount of antibacterial used in fish health management can only be a fraction of total quantity accumulated in the aquatic system. Prophylactic use of antimicrobials is more common in veterinary practice and in human medicine. In India, like in other developing countries, the use of antimicrobial drugs for treating people and animals is unregulated and antibiotics can be purchased in pharmacies, general stores, and even market stalls [50]. The human and animal wastes including their fecal matter containing non-metabolized drugs and chemicals, finally reach the aquatic destination. The use of antibiotics as feed additives in food animals has been cited as one of the reasons for the development of Antibiotic Resistant Bacteria (ARB)

in the environment [48]. Human and animal wastes have traditionally been used in Asia as sources of fertilizer for fish culture ponds. The use of waste stabilization ponds is common throughout the world [51]. The addition of manure into the fish ponds release inorganic nutrients that supports the growth of photosynthetic organisms, which are then eaten by the fish. The animal feed often contains antimicrobials, which are added to promote growth or to treat or prevent diseases [26]. Therefore, global efforts are essential to promote prophylactic use of antibiotics more judiciously in human and animal medicine including in aquaculture in order to verify the fact that unrestricted use of antibiotics is detrimental to human health, food security problems and environmental hazards due to development of Antimicrobial Resistance (AMR) [27,52]. Hence, it is high time that regional guidelines may be developed on the basis of such international rules and regulations on responsible use of drugs and chemicals in human and animal health.

Sl. No	Drug	Commercial Name	Indications	Approved Species
1.	Chorionic gonadotropin	Chorulon®	For improving spawning function in male and female brood finfish (21 CFR 522.1081)	Brood finfish
2.	Formalin	Formaldehyde solution	For the control of Protozoa and Monogenetic Tremetodes, and on the eggs of Salmon, Trout and Pike (esocids) for control of Fungi of the family Saprolegniacea, (21 CFR 529.1030)	Finfish Finfish eggs Penaeid shrimp Salmon, Trout, Catfish, Largemouth bass and Bluegill
3.	Florfenicol	Aquaflor® Type A medicated article	For the control of mortality due to enteric septicemia of catfish. The tolerance for florfenicol amine (the marker residue) in muscle (the target tissue) is 1 ppm. (21 CFR 556.283)	Channel catfish salmonids
4.	Tricaine methanesulfonate	Tricaine-S MS-222	It may not be used within 21 days of harvesting fish for food. The drug should be limited to hatchery or laboratory use, (21 CFR 529.2503)	Ictaluridae (catfish), Salmonidae (salmon and trout), Esocidae (pike), and Percidae (perch)
5.	Oxytetracycline dihydrate	Terramycin® 200	For feed use. In Salmonids, 21 days; Catfish, 21 days; Lobster, 30 days (21 CFR 558.450). Oxytetracycline tolerance in the flesh is 2.0 ppm, (21 CFR 556.500)	Catfish, Salmonids, Lobster
6.	Oxytetracycline hydrochloride	Oxymarine™ , Terramycin 343, Phennoxy 343, Tetroxy Aquatic	For feed use. In Salmonids, 21 days; Catfish, 21 days; Lobster, 30 days (21 CFR 558.450). Oxytetracycline tolerance in the flesh is 2.0 ppm, (21 CFR 556.500)	Finfish fry and fingerlings
7.	Hydrogen peroxide			Fishfish eggs Salmonids Freshwater-reared coolwater finfish Channel catfish
8.	Sulfamerazine	Sulfamerazine	It may not be used within 21 days of harvest (21 CFR 558.582). Note: This product is currently not marketed	Trout (rainbow, brook, brown)
9.	Sulfadimethoxine/Ormetoprim	Romet-30®	Withdrawal times are: Salmonids, 42 days; catfish, 3 days (21 CFR 558.575)	Catfish salmonids (trout and salmon)
10.	Chloramine-T	Halamid® Aqua		Freshwater-reared salmonids, Walleye, Freshwater-reared warm water finfish

Table 9: FDA Approved Aquaculture Drugs (permitted for application in fisheries and aquaculture).

Source: US FDA, 2017. Approved Aquaculture Drugs, U.S. Food and Drug Administration [47]

Sl. No	Name of the Drug	Indications
1.	Acetic acid	Used in a 1000 to 2000 ppm dip for 1 to 10 minutes as a parasiticide for fish
2.	Calcium chloride	Used to increase water calcium concentration to insure proper egg hardening. Dosages used would be those necessary to raise calcium concentration to 1- 20 ppm
3.	$CaCO_3$	Used up to 150 ppm indefinitely to increase the hardness of water for holding and transporting fish in order to enable fish to maintain osmotic balance
4.	Calcium oxide	Used as an external protozoacide for fingerlings to adult fish at a concentration of 2000 mg/l for 5 seconds
5.	Carbondioxide Gas	Used for anesthetic purposes in cold, cool, and warm water fish
6.	Fuller's Earth	Used to reduce the adhesiveness of fish eggs to improve hatchability
7.	Garlic (Whole Form)	Used for control of helminth and sea lice infestations of marine salmonids at all life stages
8.	Hydrogen peroxide	Used at 250-500 mg/l to control fungi on all species and life states of fish, including eggs
9.	Ice	Used to reduce metabolic rate of fish during transport
10.	Magnesium sulfate	Used to treat external monogenic trematode infestations and external crustacean infestations in fish at all life stages. Used in all freshwater species. Fish are immersed in a 30,000 mg, $MgSO_4$/l and 7000 mg NaCl/l solutions for 5 to 10 minutes

11.	Onion (Whole Form)	Used to treat external crustacean parasites, and to deter sea lice from infesting external surface of salmonids at all life stages
12.	Papain	Used in a 0.2% solution to remove the gelatinous matrix of fish egg masses in order to improve hatchability and decrease the incidence of disease
13.	Potassium chloride	Used as an aid in osmoregulation; Relieves stress and prevents shock. Dosages used would be those necessary to increase chloride ion concentration to 10-2000 mg/l
14.	Povidone iodine	Used in a 100 ppm solution for 10 minutes as an egg surface disinfectant during and after water hardening
15.	Sodium bicarbonate	Used at 142 to 642 ppm for 5 minutes as a means of introducing carbon dioxide into the water to anesthetize fish
16.	Sodium chloride	Used in a 0.5% to 1.0% solution for an indefinite period as an osmoregulatory aid for the relief of stress and prevention of shock; and 3% solution for 10 to 30 minutes as a parasitide
17.	Sodium sulfite	Used in a 15% solution for 5 to 8 minutes to treat eggs in order to improve their hatchability
18.	Thiamine hydrochloride	Used to prevent or treat thiamine deficiency in salmonids. Eggs are immersed in an aqueous solution of up to 100 ppm for up to four hours during water hardening. Sac fry are immersed in an aqueous solution of up to 1,000 ppm for up to one hour
19.	Urea & Tannic acid	Used to denature the adhesive component of fish eggs at concentrations of 15 g urea and 20 g NaCl/5 liters of water for approximately 6 minutes, followed by a separate solution of 0.75 g tannic acid/5 l of water for an additional 6 minutes. These amounts will treat approximately 400,000 eggs

Table 10: FDA low regulatory priority aquaculture drugs permitted for application in fisheries and aquaculture.

Source: US FDA, 2017. Approved Aquaculture Drugs, U.S. Food and Drug Administration [47]

Sl. No.	Antibiotics and other Pharmacologically Active Substances Banned for use in Aquaculture
1	Chloramphenicol
2	Nitrofurans including: Furaltadone, Furazolidone, Furylfuramide, Nifuratel, Nifuroxime, Nifurprazine, Nitrofurantoin, Nitrofurazone
3	Neomycin
4	Nalidixic acid
5	Sulphamethoxazole
6	*Aristolochia spp* and preparations thereof
7	Chloroform
8	Chlorpromazine
9	Colchicine
10	Dapsone
11	Dimetridazole
12	Sulfonamide drugs (except approved Sulfadimethoxine, Sulfabromomethazine and Sulfaethoxypyridazine)
13	Ronidazole
14	Other Nitroimidazoles
15	Ipronidazole
16	Clenbuterol
17	Diethylstilbestrol (DES)
18	Metronidazole
19	Fluroquinolones

Table 11: Antibiotics and other pharmacologically active substances banned for use in aquaculture, as per recommendation of Coastal Aquaculture Authority, India.

Source: http://www.caa.gov.in/uploaded/doc/Pharmacologically.pdf

Conclusion

Aquaculture has become the fastest growing sector of food production in the world. Aquaculture drugs are significant components in health management of aquatic animals, pond construction, soil and water management improve aquatic productivity, feed formulation, manipulation of reproduction, growth promotion and processing and value addition of the final product. Use of chemicals can be of great value for disease management in aquaculture, when are used properly but indiscriminate use or abuse of these can lead to significant dame to human health and environment. The present study described the existing status of aquaculture drugs used in fish and shrimp health management by the fish and shrimp farmers. Except in some parts, most of the farmers involved in aquaculture are mostly small and marginal farmers. Chemical needs are found to be minimal in moderately extensive and semi-intensive culture methods, those employing in IMCs or Tilapia or Pangus culture. This often being limited to addition of some pond fertilizers, soil or water conditioners and in some cases use of anti-parasitic preparations. Survey also revealed that most farmers did not have proper knowledge about the chemicals and they use such aqua drugs as per the advice of fish-consultants or feed/chemical suppliers in the region. Indiscriminate use of such antibiotics and chemicals may lead to development and spread of antimicrobial resistant bacteria and resistance genes and occurrence of antimicrobial residues. All that may induce a negative impact on human, fish and the environment. Hence, there is an urgent need that the policy makers, researchers and scientists should work together in addressing the issues of drugs-use in aquaculture with the view to

decrease the negative impacts. Therefore, both the government and nongovernment organizations should take initiative for implementation of better management practices and abide by aquaculture policy guidelines.

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