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Article

Aqua medicines, drugs and chemicals (AMDC) used in freshwater aquaculture of South-Eastern Bangladesh

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Abstract: A broad variety of aquaculture-related medications, drugs, and chemicals (AMDC) are extensively used in the aquaculture industry in South-Eastern Bangladesh. Fish farmers are worried about the quality of their final product, and disease outbreaks must be stopped at all costs. Farmers are sometimes one ahead of the curve when it comes to producing healthy final products by including probiotics, vitamins, and minerals into their aquaculture setups to promote early and disease-free output. However, the current study was carried out in south eastern Bangladesh, specifically in the highly dense aquaculture regions of Chandpur, Cumilla, and Feni district (17 upazilas), from November 2016 to January 2018. Questions were asked through interviews and a Focus Group Discussion (FGD) was held to gather primary data. The major target groups were aquaculture farmers, AMDC shops, pharmaceutical company employees, and hatchery owners. In this three-county area, according to the findings from the thorough research, there are a total of 33 companies that advertise 330 generics brand products via their own distributional channels. Among the available AMDC products in the study area, growth promoters were mostly abundant products among all categories while other products such as predator removal products, insecticides and ectoparasiticides, water quality and pond management, plankton producer, plankton bloom cleaner, disinfectant and disease treatment, toxic gas reducer, pH controller, oxygen supply, stress reducer, growth promoter, probiotics and antibiotics were most selling products to the farmers. The present study revealed 19 generic of antibiotics were available and prescribed by the AMDC vendors or aquaculture disease consultants (ADC) around the regions. Additionally, the research also included the dosages of AMDC and the method of administration in the aquaculture pond, which will assist both the farmers and the ADC in selecting and suggesting the appropriate medications or treatments that may be beneficial to the farmers in the long run.

Keywords: aquaculture; disease; treatments; antibiotics; probiotics; AMDC

1. Introduction

Despite the fact that it is the fastest-growing food-producing industry on the planet, aquaculture has surpassed all other animal-based food-producing industries in terms of growth (Froehlich *et al*., 2018; Leung and Bates, 2013). The fishery and aquaculture industries are critical to developing economy of Bangladesh, as they provide

millions of jobs and generate constant worldwide export revenues for the country (Sunny *et al*., 2021). Bangladesh was the fifth-largest global producer of aquaculture products in 2018, and the aquaculture industry of Bangladesh is expected to grow in the next years (Shamsuzzaman *et al*., 2020, 2017). Agriculture in Bangladesh has evolved technologically and risen in size and scope over the last few decades, diversifying, intensifying, and diversifying further (Hinchliffe *et al*., 2021; Naylor *et al*., 2021; Toufique and Belton, 2014).

In Bangladesh, freshwater aquaculture generally consists of pond aquaculture, particularly polyculture of both local and exotic species, whereas coastal aquaculture primarily consists of shrimp farming (Bostock *et al*., 2010; Boyd *et al*., 2020; Rahman *et al*., 2021). In recent years, there has been a considerable expansion of aquaculture in Bangladesh, even the mariculture is considering one of the major industries in upcoming years (AftabUddin et al., 2021; Al-Asif *et al*., 2021; Khan *et al*., 2021).

Aqua medicine, drugs and chemicals (AMDC) are increasingly being used in aquatic animal health management in Bangladesh as aquaculture expands (Al-Asif *et al*., 2021; Alam and Haque, 2021; Diana *et al*., 2013; Shamsuzzaman and Biswas, 2012). Much of this development has been focused on districts like Cumilla, Feni, Chandpur, Noakhali, where commercial Tilapia and carp polyculture culture is gaining momentum (Adhikary *et al*., 2018a; Bayazid, 2016; Hossain *et al*., 2013; Islam *et al*., 2019; Pravakar *et al*., 2013; Ullah *et al*., 2020a). Muhuri is the largest fish farming project in Feni district, encompassing the districts of Feni Sadar, Sonagazi, Chhagalnaiya, and Parshuram in Feni and Mirersarai in Chittagong. 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, the incursion of infectious pathogens and increased incidence of fish disease outbreaks (Assefa and Abunna, 2018; Biswas *et al*., 2018; Chowdhury *et al*., 2015; Kotob *et al*., 2016; Lafferty *et al*., 2015; Ullah *et al*., 2020a).

In Bangladesh and other Asian nations, many bacterial, viral, fungal, and parasite diseases have been observed in aquaculture (Adhikary *et al*., 2018b; Ahmed *et al*., 2007; Faruk *et al*., 2004; Hasan *et al*., 2014; Majumder *et al*., 2001; Shabuj *et al*., 2016; Sharif and Al-Asif, 2015; Siddique *et al*., 2021; Vaumik *et al*., 2017). A large number of aquaculture medicines and chemicals are currently being utilized to prevent production loss as a consequence of this phenomenon (Al-Asif *et al*., 2021; Chowdhury *et al*., 2015; Rahman *et al*., 2019; Ullah *et al*., 2020).

Besides the control of fish health, aqua medicines and chemicals are required for pond preparation, soil and water management, natural aquatic production improvement, feed formulation, and fish growth (Al-Asif *et al*., 2021; Chowdhury *et al*., 2015; Faruk *et al*., 2021; Hossain *et al*., 2014; Ullah *et al*., 2020a). Around 1484 aqua-medicines generics are being found and commercialized by 100 pharmaceutical businesses over Bangladesh in past decade (Al-Asif *et al*., 2021). Many aquaculture consultants, representatives from pharmaceutical and feed companies, and chemical sellers are involved in the marketing chain for distributing such products to end-users (Al-Asif *et al*., 2021; Sharker *et al*., 2014). Lime, disinfection, rotenone, various inorganic and organic fertilizers, phostoxin, salt, dipterex, antimicrobials, potassium permanganate, copper sulphate, formalin, sumithion, melathion, and other chemicals are frequently employed in aquaculture of Bangladesh (Adhikary *et al*., 2018b; Al-Asif *et al*., 2021; Biswas *et al*., 2018; Chowdhury *et al*., 2015; Faruk *et al*., 2004; Rahman *et al*., 2019; Ullah *et al*., 2020a). The use of these chemicals in fish aquaculture units is currently being supported by a number of pharmaceutical companies and other chemical sellers, despite the fact that most farmers are completely unaware of the stability of drugs and effectiveness (Al-Asif *et al*., 2021; Lulijwa *et al*., 2020). In recent years, a number of international and national organizations have voiced significant concern about the overuse or abuse of these drugs, which has often led in the development of Antimicrobial Resistance (AMR), presenting a serious threat to public health (Cabello *et al*., 2013; Hoque *et a*l., 2020; Lulijwa *et al*., 2020; Neela *et al*., 2015; Rasul and Majumdar, 2017; Thornber *et al*., 2019; Watts *et al*., 2017).

Fishermen are compelled to use a variety of aqua medicines and chemicals in a sequential manner, according to the effects of each drug or chemical. It is up to them to determine the dosage of chemicals based on their own expertise, product instructions on the bottle, or discussions with chemical suppliers or farmers (Al-Asif *et al*., 2021; Hasan *et al*., 2015). Consequently, appropriate doses of these aqua medicines and antibiotics are regularly ignored, presenting a danger to aquaculture as well as to the general public (Hinchliffe *et al*., 2018; Hoque *et al*., 2020; Liu *et al*., 2021; Reverter *et al*., 2020; Schar *et al*., 2021). Over the past decade, there has been a significant increase in the amount of information accessible regarding aquaculture drug use and its implications for human health, environmental protection, and the sector's long-term sustainability (Lulijwa *et al*., 2020).

As aquaculture grows in this area, more pesticides, antibiotics, and aqua medicine are required to keep it running well (Al-Asif *et al*., 2021). The area, on the other hand, has not had a comprehensive study of the marketing and availability of different aquaculture medicines, pharmaceuticals, and chemicals performed in order to determine their availability (Al-Asif *et al*., 2021; Rahman *et al*., 2019; Ullah *et al*., 2020a). As a

consequence, the present study investigated the market availability and use patterns of different aqua-medicines, pharmaceuticals, chemicals, and formulations in the major aquaculture zones of Bangladesh.

2. Materials and methods

2.1. Study area and periods

The data were collected from three district of south east Bangladesh namely, Cumilla, Chandpur, and Feni district (Figure 1). A total 17 upazilas (sub-district) were selected for conducting the survey from November 2016 to January 2018. The study covered nine upazila, namely Comilla Sadar, Comilla Sadar Dakkhin, Daudkandi, Muradnagar, Brahmanpara, Burichang, Chauddagram, Laksam and Barura upazilla from Cumilla district; four upazila *viz*. Chandpur Sadar, Hajigonj, Faridganj and Matlab Uttar upazila from Chandpur district, while four upazila were considered from Feni district such as, Feni sadar, Sonagazi, Parshuram, and Daganbhuiyan (Figure 1).

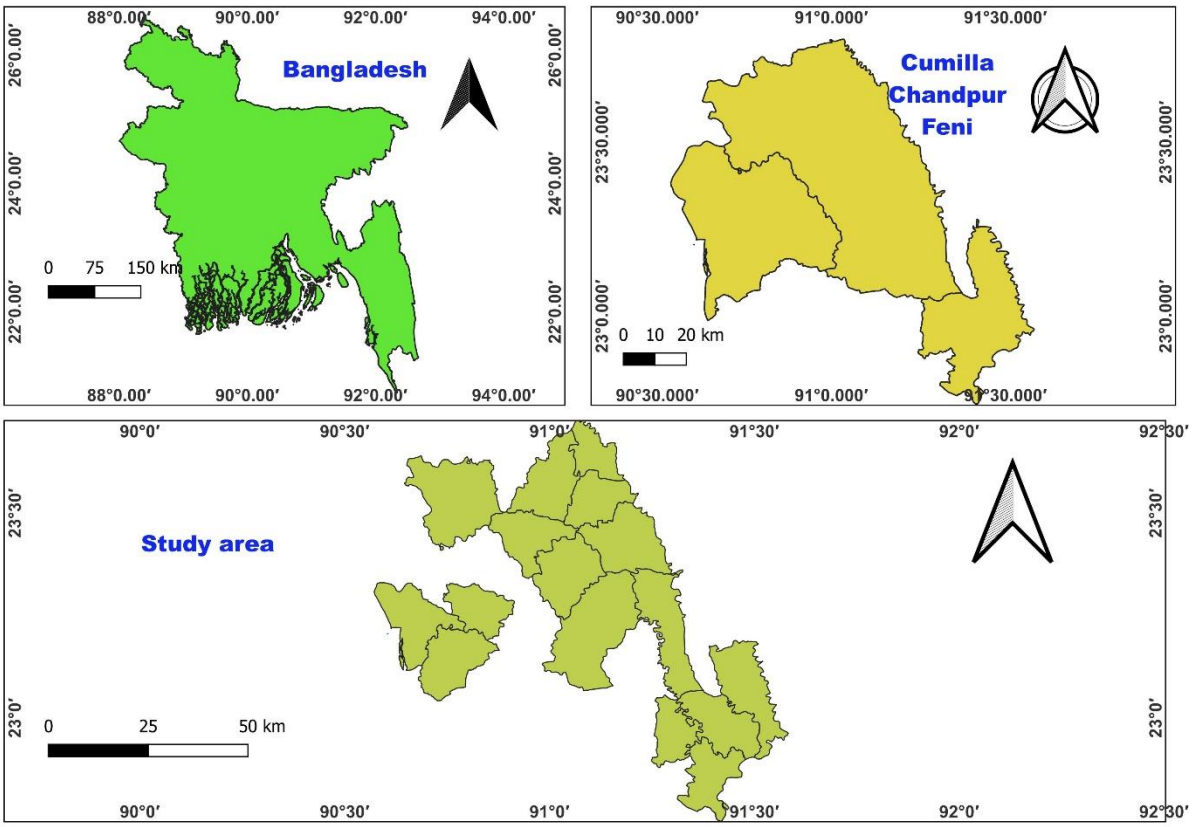

Figure 1. The study covered three south eastern districts of Bangladesh.

2.2. Data collection

Data were collected from fish farms, feed shops, aqua shops and medical representative of Pharmaceuticals companies at their offices. Both primary and secondary data were used to finalize the study process. Several survey techniques were adopted for gathering data, such as face-to-face interview, focus group discussion (FGD), Participatory Rural Appraisal (PRA) and so on to gather the aqua medicines, drugs and chemicals (AMDC) status in the market, fish disease in the farms, business strategies by the AMDC companies and their representatives.

2.2.1. Primary data collection

First-hand information was gathered through questionnaire interviews with representatives from culture farms, chemical merchants, and medical representatives from pharmaceutical companies. During the visit to the nurseries and culture pond, the following aspects of chemicals and fish toxicants were considered important: the purpose of using chemicals or toxicants, variations in application methods, effectiveness of chemicals or toxicants, and toxicants, variation in applied dose of chemicals or toxicants, or toxicants by the government and availability of the chemicals, specific toxicity of the chemicals, and specific toxicity of the toxicants.

2.2.1.1. Questionnaire interviews

The questionnaire form was filled in by interviewing from 157 farmers, 105 chemical sellers and 33 medical representatives of Pharmaceuticals Company directly from the study area.

2.2.1.2. Focus Group Discussion (FGD)

For this study, one of the PRA tool such as Focus Group Discussion (FGD) was conducted in fish farms (n=20), hatcheries or gher owner (n=10), fish farmers, chemical sellers (n=135), and medical representatives (n=50) of Pharmaceuticals Company. In this study, FGD was used to get an overview of particular issues such as the existing problems associated with the use of aquaculture drugs. A total of 10 FGD sessions was conducted where each group size of FGD was 21.5 people. FGD session was held in front of hatchery or gher, representative offices, chemical sellers shop and so on.

2.2.1.3. Crosschecked interviews

After collecting the data through questionnaire interviews and FGD, crosscheck interviews were conducted with Upazila Fisheries Officer, Assistant Fisheries Officer, relevant NGO workers, chemical seller and medical representative of Pharmaceuticals Company at their offices.

2.2.2. Secondary data collection

Secondary source of information consist of published material such as journals (for example, Al-Asif *et al*., 2021), textbooks, university thesis (up to post-graduate level), newspaper and other sources. Moreover, appropriate government and non-government organizations reports were also taken into consideration for gathering information. The existing problems associated with the use of aquaculture drugs were also collected from the secondary source.

2.3. Data processing and analysis

The data was analyzed using tabular and descriptive statistical techniques. The summary tables were prepared in accordance to the objective of the study. Data collected from various sources was entered into a data base system using Microsoft office Software. The processed data were transferred to a master sheet from which classified tables were prepared revealing the findings of the study. At each stage of survey data sheets were compared with original data sheets to ensure the accuracy of data entered.

3. Results

3.1. Aqua drugs and chemicals producing companies

The current study found, a total 33 companies were either producing or marketing aqua medicines, drugs and chemicals (AMDC) products targeting freshwater aquaculture in South-Eastern part of Bangladesh. ACI Animal Health Ltd., Square Pharmaceuticals Ltd., Acme Laboratories, Novartis Animal Health Ltd., Eon Animal Health., Organic Pharmaceuticals Ltd., Renata Ltd., CP Company, Rals Agro Ltd., and many other companies were noticed that produced, imported and marketed different AMDC products for freshwater aquaculture in that regions (Table 1). The most of the imported products were imported from countries such as India, USA, Thailand, Taiwan, Indonesia, Malaysia and Spain.

Table 1. AMDC producing, importing and marketing companies available in the South-Eastern part of Bangladesh.

Name of companies	
Eon Animal Health	VnF Agro Ltd.
Square Agrovet Division	One Pharma Ltd.
Novartis Pharmaceuticals Ltd.	NAAFCO Pharma Ltd.
ACI Animal Health	Bismillah Enterprise Ltd.
SK+F Animal Health.	NutriHealth Ltd.
The ACME Laboratories Ltd.	Advanced Agrotech (BD) Ltd.
Nature Care Ltd.	Chemical Seller
Fishtech (BD) Limited	Promim Agro vet Industries
Penta Agrovet Ltd.	PRAN Agro Business Ltd.
Organic Pharmaceuticals Ltd.	Univet Ltd.
First Care Agro Ltd.	Save and Safe Agroscience Bangladesh
Lion Overseas Trading Company	Verno Bio-Splutions Ltd.
Catapol Bioscience Ltd.	Agrosol Bangladesh Company

Avon Animal Health	Uttara Tread bd.
Navana Limited	Century Agro Ltd.
Renata Animal Health	Ultimate (BD) Ltd.
S.S.S Agro Care Ltd.	

3.2. Categorization of AMDC products

According to the findings of the current study, the total number of AMDC goods accessible in the study region totaled 330 items, comprising highest number of growth promoters (GP) (total 59 items; 17.88%), followed by disinfectant and disease treatment (DD) (total 49 items; 14.85%), water quality and pond management (WQPM) (total 47 items; 14.24%), oxygen supply (OS) (total 36 items; 14.24%), toxic gas reducer (TGR) (total 30 items; 10.91%) and rest of the products were found to be less than 30 items and 10% of total numbers. However, We found antibiotics contributes 19 items and 5.76% of the total AMDC available in the study area (Figure 2).

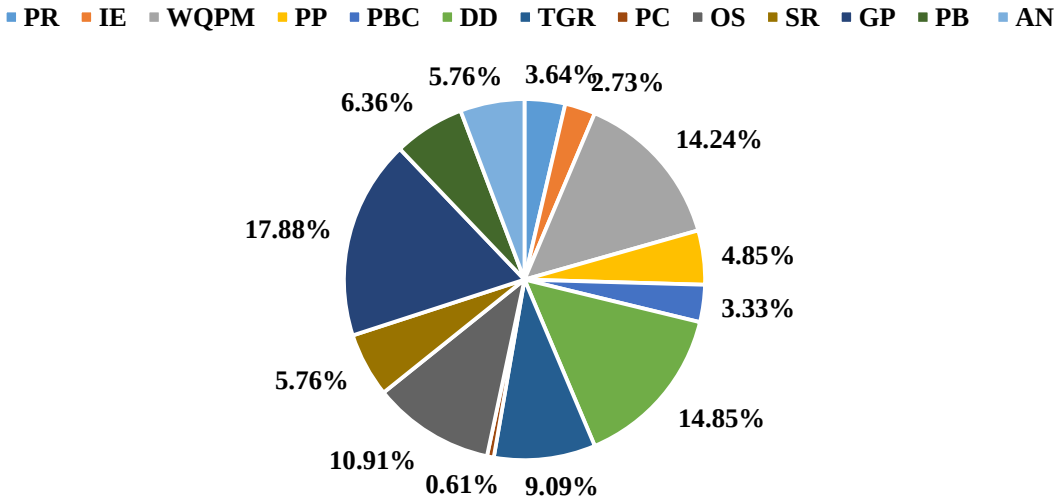

Figure 2. Categorization of AMDC products available in south-eastern part of Bangladesh (Predator removal=PR; insecticides and ectoparasiticides=IE; water quality and pond management=WQPM; plankton producer=PP; plankton bloom cleaner=PBC; disinfectant and disease treatmen=DD; toxic gas reducer=TGR; pH controller=PC; oxygen supply=OS; stress reducer=SR; growth promoter=GP; probiotics=PB and antibiotics=AN).

3.2.1. AMDC used as predator removal

Farmers use rotenone powder to remove predator and unwanted fish. Rotenone is provided by different pharmaceutical company. The dose of Rotenone depends on water depth and company's products. Following rotenone powder was found in the study (Table 2). Mainly Rota Plus, Napko Glod, Hunter, Phostoxine, Aquanone were used to remove predator and unwanted fish.

Table 2. AMDC used for removal of predator from aquaculture setup.

Trade Name	Active Ingredients	Doses/ 3-6 feet water	Sources
Aquroted gold	Rotenone 9%	35 g decimal-1 ft-1 depth	ACI Animal Health
T Seed Cake	Saponin 15-16%	800 g decimal-1 ft-1	ACI Animal Health
Rota Plus	Rotenone 9%	30 g decimal-1 ft-1 depth	ACI Animal Health
Rotenil	Rotenone 9%	1kg/ 100 dec (depth 4-5 ft.)	SK+F Pharmaceuticals Ltd.
Napko Glod	Rotenone 9%	20 g decimal-1 ft-1 depth	NAAFCO Pharma Ltd.
Hunter	Rotenone 9%	18g decimal-1 ft-1 depth	Eon Animal Health
Aquanone	Rotenone 9 %	5-7kg/100 dec	Square AgroVet Division
Phostoxine	Almmonim phosphide	2-3 Tablets decimal-1	Fishtech (BD) Limited
Raj-fume 56%	Almmonim phosphide	2 Tablets decimal-1	Aquaculture International Co. BD
Aquanone	Rotenone 9 %	5-7 kg/100 dec	Square AgroVet Division
Fewmitix 56%	Almmonium Fosfide	5 tablet/ decimal/ depth 5 ft.)	One Pharm Animal Health
Rotenone	Rotenone 9 %	6-7 kg/100 dec	First Care Agro Ltd.

3.2.2. AMDC used as insecticides and ectoparasiticides

Wide ranges of chemicals or formulations are being used by the fish farmers for the treatment of parasitic infestations caused by fish louse (*Argulus* sp.), gill flukes (*Dactylogyrus* sp.), *Myxobolllus* sp., ich (*Ichthyophtherius* sp.) and gill maggot (*Ergasillus* sp.) (Table 3).

Table 3. AMDC use for controlling insects and ecto-parasites.

Trade Name	Active Ingredients	Doses/ 3-6 feet water	Sources
Argulex	Trichlorofon-40%	12-13 ml/dec/3 ft depth	Eon Animal Health
Sumithion		5- 8ml/dec/3ft depth	Setu Corporation Ltd.
Engreb	Cypermethrine 10%	7 ml/33 dec /ft depth	Eon Animal Health
Paratics	Sumithione 10%	100 ml/100 dec, 3 ft depth	Advanced Agrotech (BD) Ltd.
Acemec 1% Oral Solution	Iberrmethrine	300 ml/100 dec, 5 ft depth	ACI Animal Health
Deletix	Deltametrin-1.75%	50 ml/100 dec, 4 ft depth	Fishtech (BD) Limited
Deltacin	Deltametrin-1.75%	50 ml/100 dec, 4 ft depth	Save and Safe Agroscience Bangladesh
Terminate	Deltametrin-1.75%	50 ml/100 dec, 4 ft depth	Ultimate (bd) Ltd.

3.2.3. Water quality and pond management

Pond preparation is critical in order to increase the productivity of the whole system. Again, maintaining optimal water quality is very important in determining the success or failure of fish production to a significant degree. This includes pH, total alkalinity, total hardness, dissolved oxygen (DO), ammonia, and nitrite-nitrate concentrations, among other things. A wide range of chemicals, including Mega Zeo plus Acme's Zeolite, Matrix, Pond Gurd, Aqua Lime, Bio Aqua, Geotox, and others, were frequently employed in the pond preparation process and for the maintenance of optimal water quality in the survey area (Table 4).

Table 4. AMDC use for pond preparation and water quality management.

Trade Name	Active Ingredients	Doses/ 3-6 feet water	Sources
JV Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, Mn, P	5-7 kg/33 dec	Eon Animal Health
Matrix	SiO_2, Al_2O_3, Fe_2O_3, CaO,	6-10 kg/100 dec	Eon Animal Health
Super Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, LoI, K_2O	20-30kg/100 dec	Avon Animal Health
Raw Lime	$CaCO_3$, $Ca(OH)_2$,	1–2 kg/dec	Chemical Seller
Mega Zeo Plus	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na2O	20-25kg/ 100 dec	ACI Animal Health
Mega Zeo Gold	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, $Na_2O + O_2$	20 kg/ 100 dec	ACI Animal Health
Zeoren	Aluminum sodium silicate-75%	20-30/100 dec	Renata Animal Health
Zeo Prime	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, LoI, K_2O	20-24 kg/100 dec	SK+F Animal Health
Quality Zeolite	SiO_2, Al_2O_3, Fe_2O_3 CaO, MgO,	20-25 kg/100 dec	Quality Fish Feed Ltd.
Aalo Zeolite	SiO_2, Al_2O_3, Fe_2O_3 CaO, MgO,TiO_2, MnO_2, K_2O, Fe_2O_3, pH	15-20 kg/100 dec	PRAN Agro Business Ltd.
Pure Lime	$CaCO_3$	1 kg/ dec	PRAN Agro Business Ltd
Vernolite plus	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, C. E. C = 400	5-10 kg/100 dec	Verno Bio-Solutions Ltd.
Zeo Pel	No label found		SK+F Pharmaceuticals Ltd.
Geo Rich	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O	15-25 kg/100 dec	Opsonin Agro vet Division
Nap Zeo	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	10-16 kg/100 dec	NAAFCO Pharma Ltd.
Pond Gurd	Al_2O_3, Yucca, Probitics		ACI Animal Health
Pond Life	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na2O, Probitics		ACI Animal Health
Geotox	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20-25 kg/100 dec	Novartis Pharmaceuticals Ltd.
One Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, Mn_2O, P_2O_5	25-30 kg/100 dec	One Pharm Animal Health
Aqua magic	No label found	05-08 kg/100 dec	Fishtech (BD) Limited
Aqua-Zeo Plus	SiO_2, Al_2O_3, Fe_2O_3 CaO, MgO, Na_2O, K_2O	8 kg/33 dec	Advanced Agro Ltd.
Miracol lime mila	No label found	100 gm/dec	The ACME Laboratories Ltd.

Alpha Zeolite	SiO_2, Al_2O_3, Fe_2O_3 CaO, MgO, Na_2O	20-30 kg/100 dec	Biswas Agrovet Limited
Acme's Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	21 kg/100 dec	The ACME Laboratories Ltd.
Zeo Fresh Granular	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	24 kg/100 dec	Square AgroVet Division
Aqua Lime	CaO	250-500 gm/dec	ACI Animal Health
Bio-tuff	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO	15–20 kg/100 dec	Organic Pharmaceuticals Ltd.
Aquazet	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O Ti_2O, LoI	20–30kg/100 dec	Lion Overseas Trading Company
Zeonex	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20–30 kg/ 100 dec	Anex vet (pvt.) Ltd.
Fish Grow	S, Co,Mg, K, N, P, Ca	400 ml/ 100 dec	Bismillah Enterprise Ltd.
Bis Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20–30 kg/ 100 dec	Avon Animal Health
Zeolite Plus	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20–30 kg/ 100 dec	Penta Agrovet Ltd.
Green Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2	20–25 kg/ 100 dec	Organic Pharmaceuticals Ltd.
Zeocare	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20-22 kg/ 100 dec	Nature Care
Major Zeolite	SiO_2, Al_2O_3	30–40 kg/ 100 dec	Univet Ltd.
Pontox Plus	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	15-20 kg/ 100 dec	Rals Agro Ltd.
Well Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	18 kg/ 100 dec	SK+F Pharmaceuticals
Soil Cure	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O	20-30 kg/ 100 dec	VnF Agro Ltd.
Biotics	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, Multuenzyme, Yeast,	7-10 kg/ 100 dec	Advanced Agrotech (BD) Ltd.
Zeo Master	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K2O, P, Mn, C.E.C 215 mcq/100gm	20-21 kg/ 100 dec	Nurtihealth Ltd.
Promim Water Wash	$CaCO_3$, $CuSO_4$, $Al_2(SO_4)_3$ $10H_2O$, K_2SO_4, $FeSO_4$, C_6H_5COONa,	4kg/ 33 dec	Promim Agro vet Industries
Zeo Magic super	Natural Zeolite , Probiotics, Gas remover	10 kg/ 100 dec	First Care Agro Ltd.
Zeo First	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K2O, P, Mn, C.E.C 214 mcq/100gm	15-20 kg/ 100 dec	First Care Agro Ltd.
Good Earth	No label found	2-4 kg/ 100 dec	Catapol Bioscience Ltd.
Fish Zeolite	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O	20-22kg/ 100 dec	Uttara Tread bd.
Zeo Tiger	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, P_2O_5, TiO_2, MnO_2, LOI, C.E.C.= 80-160 mcq/100 gm	10-20 kg/ 100 dec	Univet Ltd.
Zeolite Gold	Zeolite, Yuuka, Probiotics	1.5-2 kg/100 dec	Uttara Tread bd.

3.2.4. AMDC as plankton producer

The primary constituent of the aquaculture food web, phytoplankton, is found in abundance in natural waters, but the natural quantity of phytoplankton is insufficient to support desired levels of shrimp and fish production. In addition to increasing the natural fertility of ponds, fertilizers also help to improve crop yields. Many aquaculture farmers, on the other hand, have shifted to feed-based aquaculture in order to boost output beyond what is feasible with conventional fertilizers. Different types of chemical were used for growing phytoplankton and Zooplankton in the study area (Table 5).

Table 5. AMDC used for plankton enhancer in the aquacultures setup in the study area.

Trade name	Active ingredient	Doses/3-6 ft water	Sources
Plankton Grow	N, P, K, Ca, Mg, others	1.5 kg/33dec	ACI Animal Health
Benthods	Compost Urea, Vitamin, Mineral, Ammonium silicate	150 gm/dec.	ACI Animal Health
Vita Plakton	N, P, K, Ca, Mg	2 kg/100 dec	ACI Animal Health
Pond Ferti	Organic Fertilizer		ACI Animal Health
Aqua Green G	Sea-weed Extract, Enzyme precursors, Micronutrients	4 kg/100 dec	Square AgroVet Division
Bio Pond	Vitamin, Mineral, Probiotics and Prebiotics	No recommendation found	SK+F Pharmaceuticals Ltd.
Aqua cal	Ca-22% and Sulper-17%	5 kg/33dec	ACI Animal Health
Green Food	Dicalcium phosphate, and all mineral	4-5 kg/100 dec	Ultimate (bd) Ltd.

	composition		
Aqua Food	Fulvic acid, minerals, organic complex, plant growth stimulator	600-700 gm/100 dec	Ultimate (bd) Ltd.
Well Bloom	Silicon, Plankton Growth promoter	4 liter/100 dec	First Care Agro Ltd.
Greenmix Aqua	$CaCO_3$, Phosphorous, Humus, Probiotics	1-2 kg/100 dec	Advanced Agrotech (BD) Ltd.
Live Food	Multivitamin, Multimineral, Dicalcium Phosphate	5-6 kg/100 dec	Advanced Agrotech (BD) Ltd.
Nugel	Growth promoter	3 liter/100 dec	NAAFCO Pharma Ltd.
All plankkot- L	Minerals with probiotics	2.5 ml/100 dec	One Pharm Animal Health
Promim Aqua Vita	$MgSO_4$, Ca $(PO_4)_2$, $CoSO_4$, S, B C_6H_5COONa	12 kg/ 100 dec	Promim Agro vet Industries
Verno Bloom Plus	Essential Macro and Micro Nutrients with growth promoter	4 kg/100 dec	Verno Bio-Solutions Ltd

3.2.5. AMDC as plankton bloom cleaner

This rapid growth and dense buildup of algae causes deoxygenation of the water and the production of poisonous chemicals known as phycotoxins, which are detrimental to both aquatic and human life. Different types of AMDC were used for removing or controlling the toxic algae and phytoplankton growth in the study area (Table 6).

Table 6. List of plankton bloom cleaner.

Trade name	Active ingredient	Doses/3-6 ft water	Sources
No Alage	Chlro-alkali finale urea concentrated-4%	1 liter /100 dec	ACI Animal Health
Fytonil	Copper, EDTA,Copper citrate, Inert ingradients	3-4 litter/100 dec	Agrosol Bangladesh Company
Killmax Plus	Copper-50 gm, Inter Composition	3-5 liter/acer	Save & Safe Agroscience Bangladesh
Met Alage	Alimental copper-10%, Ethylene Diamin-32%, Natural Fungicide-58%	2-4 litter/100 dec	Univet Ltd.
Droper	Chlro-alkali finale urea concentrated-9%	0.500-1 liter /100 dec	Univet Ltd.
Faito Alage	No label found	2 liter /100 dec	No label found
Kill Alage	No label found	1 liter /100 dec	No label found
Cupper Sulphet	$CuSo_4$		Chemical
Promim Algae Clear plus	$CuSo_4$, C_6H_5COONa, EDTA, BKC	1liter/100 dec	Promim Agro vet Industries
Promim Aqua Solution Plus	NaOH, $CuSo_4$, C_6H_5COONa, EDTA, BKC	3 liter/100 dec	Promim Agro vet Industries
Verno Drop	No label found	100 ml/ 33 dec	Verno Bio-Solutions Ltd

3.2.6. AMDC used as disinfectant and disease treatment

In aquaculture, a variety of chemicals are available for use as disinfectants and as a measure of better health management. The active components in a wide range of antimicrobial disinfectants or sanitizers typically used for fish health management in the study area. Timsen, pathonit, Virex, Aquakleen, Pathocide, BKC (Benzalkonium chloride), potassium permanganate, copper sulphate, Bactisal, Virusnip, and Polgard plus are some of the regularly used chemical preparations for disease control. Spa can be used to heal diseases as well as encourage growth. BKC is used to control bacterial illness while formalin is used to control protozoan parasite infestation (Table 7).

Table 7. AMDC used as disinfectant and disease treatment.

Trade name	Active ingredients	Doses /3-6 ft water	Sources
Timsen	n-Alkyl dimethyl benzyl ammonium chloride-40%, stabilized urea-60%	20 g/33 dec. (for prevention), 80 g/33 dec. (for treatment)	Eon Animal Health
Pathonil	n-Alkyl dimethyl benzyl ammonium chloride-80%	200 ml/33 dec.	ACI Animal Health
Acidin	Iodine		ACI Animal Health
Germnil	BKC-50% + Glutaraldehyde	No recommendation found	NAAFCO Pharma Ltd.
Bleaching powder	Clorine	0.1-1 ppm	Chemical Seller
Eon CTC	Efinol	5–8 gm/liter water	Eon Animal Health
Emsen	n-Alkyl dimethyl benzyl ammonium chloride + stabilized urea	80 gm/33 dec	SK+F Pharmaceuticals Ltd.
Aquaxide Plus	Alkyl dimethyl benzyl ammonium chloride + Glutaraldehyde	500-750 ml/100 dec	Advanced Agrotech (BD) Ltd.
Virokill Aqua	Alkyl dimethyl benzyl ammonium chloride-80%	500-750 ml/100 dec	Advanced Agrotech (BD) Ltd
Onesol P	n-Alkyl dimethyl benzyl ammonium chloride-40%, stabilized urea-60%	5 gm/dec	One Pharm Animal Health
Onesol L	Tetradyile Trimethyle Ammonium Bromide-6.7% + Alkyl dimethyl benzyl ammonium chloride-83%	5-10 ml/dec	One Pharm Animal Health
BKC	n-Alkyl dimethyl benzyl ammonium chloride-80%	500-600 ml/100 dec	VnF Agro Ltd.
BKC-800	Benzal konium chloride- 80%	500 ml/100 dec	First Care Agro Ltd.
Protector Plus	Alkyl dimethyl benzyl ammonium chloride + Glutaraldehyde	350-500 ml/100 dec	Ultimate (bd) Ltd.
Topper Aqua	Alkyl dimethyl benzyl ammonium chloride-80%	350-500 ml/100 dec	Ultimate (bd) Ltd.
Mector BKC	Alkyl dimethyl benzyl ammonium chloride-80% + Acetic acid- 10% Glutaraldehyde -5%	300-500 ml/100 dec	Univet Ltd.
Oxykol	Per acetic acid-90 gm/kg	250-500 gm/100 dec	Univet Ltd.
Aqua Guard	Alkyl dimethyl benzyl ammonium chloride-80% + Teradecyl trimethyl ammonium bromide-6.7%	300-600 ml/100 dec	PRAN Agro Business Ltd
Aquasen	Alkyl dimethyl benzyl ammonium chloride-40% + Alkyl dimethyl benzyl ammonium chloride-60%	100 gm/100 dec. (for prevention), 250 gm/33 dec (for treatment)	PRAN Agro Business Ltd
Superio	Iodofour	500 ml/100 dec	Verno Bio-Splutions Ltd
Bromi-5	Bromine 5%	5-10 ml/dec	VnF Agro Ltd.
Promim Anti-virus	Alkyl dimethyl benzyl ammonium chloride + ISO Propanol Methylenblue C_6H_5COONa	500ml/ 33 dec.	Promim Agro vet Industries
Promim Aqua Qripus	$CaCo_3$, $KMnO_4$, P, Mn $C_{37}H_{27}N_3Na_2O_9S_3$, P, NaCl, C_6H_5COONa	2kg/ 33 dce	Promim Agro vet Industries
Formalin	38% Formaldehyde	1–3 ppm	Chemical Seller
Lenocide	Ankul benzyl dimethyl ammonium chloride + poly-2	500–1000 ml/100 dec	Nature care

	deoxy-2 amino glucose		
Omicide	Benzyl ammonium chloride + urea	200 ml/33 dec.	Lion overseas trading company
Virex	Potassium Peroxymono sulphate 50%	100-200 /33 dec	ACI Animal Health
EDTA	Sodium thiosulphate	0.1–1 ppm	Chemical seller
Water clear 300/L	Sodium thiosulphate	2–3 L/100 dec.	Organic pharmaceuticals Ltd.
Aquakleen	Tetradesail Tri-methyl Amonium bromid, BKC	0.5-1 L/100 dec	Square AgroVet Division
Microbite	Benzal konium chloride+ providin Iodine	100-150 ml/ 33 dec	Nutrihealth Ltd.
Albez	Doxycyclin, colistine sulphate + vitamin premix + mineral	No recommendation found	Syngenta pharmaceuticals Ltd
BKC	Benzal konium chloride	Spread with water, 0.5 ppm	Chemical seller
Polgard plus	3-Methyl and 4-Methyl two chain brominated compound	500 ml/100 dec	Fishtech (BD) Limited
Farmsafe	Didisyle Dimethyl Ammonium chloride + Ethylalcohol +Yucca	250-300 ml/100 dec	Catapol Bioscience Ltd.
Bioxide	Alkyl dimethyl benzyl ammonium chloride-80% + Glutaraldehyde -50%	350-500 ml/100 dec	Save and Safe Agroscience Bangladesh
Virocin	Dichlro Ammonium chloride-1% + Iodine-3% + Dimethyl blue	200-300 gm/100 dec	Agrosol Bangladesh Company
Bactisal-80	Ankul benzyl dimethyl ammonium chloride	350 ml/ 100 dec	First Care Agro Ltd.
Well Guard	Bromine- 5%	500 ml/ 100 dec	First Care Agro Ltd.
Lenocide	Ankul benzyl dimethyl ammonium chloride + poly-2 deoxy-2 amino glucose	500 ml/ 100 dec	Nature care Ltd.
Virusnip	Potassium peroxymonosulphate 50%, Sodium dichloroisocyanurate 5%, Excipients 45%	300-400g/ 100 dec	Novartis Animal Health
Germclean	Alkyl dimethyl benzyl ammonium chloride	1-1.5 litter/100 dec	Uttara Tread bd.
Auqa Fair	$C_{17}H_{30}CIN$-40%, CH_3COON-10%, HCHO-5%, 3CHO-5%, OHCCHO-5%	400-600 gm/ 100 dec	Uttara Tread bd.
Potash	$KMnO_4$	5-15 mg/ 100 dec	Chemical seller
Salt	NaCl	500-1000g/ 100 dec	Chemical seller
Malachite green	$C_2H_2O_4$	1ppm; 1min; dip	Chemical seller
Melethion	Active melathion	500g/ 100 dec	Chemical seller
Methylene blue	$C_{10}H_{18}CIN_3SxH_2O$	2-3ppm bath for 1h/10-20 mg/L for 15 min.	Chemical seller
Copper Sulphate	$CuSO_4$	15-25 mg decimal	Chemical seller

3.2.7. AMDC used as toxic gas reducer

Farmers have been observed adding a gas removal agent to their culture ponds in order to remove organic and inorganic wastes that are generating gas. Some of the probiotics utilised in feed included MI Plus, Yuka, Ammonil, Gas check, Aqua Pure Powder, Gasonil, Pond Kleen, Bio-Aqua-50, Gasonex plus, Gas kit, and Gasonex plus plus, among other things (Table 8).

Table 8. List of available AMDC used as toxic gas reducer in the study area.

Trade Name	Active ingredients	Doses/3-6 ft water	Sources
MI Plus	*Bacillus subtillis, Bacillus licheniformis, Bacillus megaterim, Bacillus pumilus, Bacillus amyloliqefaciens*	40-50 tablet/ 100 dec	ACI Animal Health
Yuka	Yucca plant extract, Saponin Components Glyco components	300 ml/ 100 dec	Opsonin Agrovet Division
Bio-Aqua-50	Yucca plant extract, Saponin Components Glyco components	60-70 ml /33 dec	Eon Animal Health
Bio- Aqua liquid	Yucca plant extract	200-300 ml/ 100 dec	Nutrihealth Ltd.
Faast	Yucca plant extract, Saponin Components Glyco	100 gm/33 dec.	Nutrihealth Ltd.
Gaskleen Aqua	Natural element, Beneficial Microorganism, Digestive Enzyme	200-400 gm/ 100 dec	Advanced Agrotech (BD) Ltd
Ammonil	Yucca plant extract, *Bacillus subtillis, candida utilis*	100-200 g/ 100 dec	Noverties Pharmaceuticals Co. Ltd.
Gas stop	*Bacillus subtillis* Al2O3 SiO2	500 mg/100 dec, 3 weeks	Organic pharmaceuticals Co. Ltd.(BD)
Gasonil	*Bacillus subtillis*		SK+F Animal Health
Pond Kleen	Yucca plant extract, , Saponin and Glyco components	300 ml / 100 dec	ACI Animal Health
ACI Yucca Plus	Yucca plant extract, *Bacillus subtillis, Rhodoseudomonas*	300 ml / 100 dec	ACI Animal Health
Victor Aqua	Yucca plant extract	300-400 gm/ 100 dec	Ultimate (bd) Ltd.
Gass free aqua	Yucca plant extract, Saponin and Glyco components	0.500-1kg/ 100 dec	Renata Animal Health
Ammorid	Nitrifying and Denitrifying Bacteria	0.500-1liter/ 100 dec	Renata Animal Health
First Yucca	Yucca plant extract	200-300ml/ 100 dec	First Care Agro Ltd.
First Pro Yucca	Yucca plant extract, Probiotics	175-200 gm/ 100 dec	First Care Agro Ltd.
Bio Cure	Yucca plant extract, Probiotics	10-12 kg/ 100 dec	First Care Agro Ltd.
Ammosol Liquid	Natura Yucca plant extract l Biochemical compounds	200-400 ml/ 100 dec	Save and Safe Agroscience Bangladesh
Gas Killer	Yucca plant extract with probiotics	200-400/ 100 dec	PRAN Agro Business Ltd
Gastrap	Lactic acid *Bacillus* sp. *Bacillus subtillis* Cellulase, Hemicellulase, amylase	200 mg/ 100 dec	Square Agrovet Division
Biomax Power	Maximum consortium of probiotics bio-fixed on a calcareous matrix	4-5 kg/ 100 dec	Square Agrovet Division
Aqua Pure Powder	Hydrate sodium alumino silicate with natural adsorbing and deodorizing agent, Highest CEC	8-10 kg/ 100 dec	Square Agrovet Division
AMOVER Remover	Essential Bacteria, Yeast, Enzyme, Nitrogen Factor, catalyst, Oxygen	300-400 gm/ 100 dec	VnF Agro Ltd.
Aqua Magic	*Azotabactor chorococcum, Bacillus subtillis, candida utilis*	400g/ 100 dec	Fishtech (BD) Limited
Pond D tox	Pracoccus pantotrophus	4 ppm	Fishtech (BD) Limited
Gas Check Plus	Tetra acetyl ethylene diamin	200 g/ 100 dec	First Care Agro Ltd.
Gas kit		200-300 g/ 100 dec	Catapol Bioscience ltd.
Gasonex plus	Na-lorile ether sulphate	200-400 mg/kg, Zeolite	Fishtech (BD) Limited
Gas Clean	Probiotics and enzyme	200-300 gm/acer	Uttara Tread bd.
Metox_GR Pro	Yucca plant extract, Probiotics, enzyme	200 gm/ 100 dec	Univet Ltd.

3.2.8. AMDC as pH controller

The pH of freshwater environments may vary significantly across daily and seasonal timescales, and most freshwater species have evolved to withstand a rather wide pH range. Animals, on the other hand, can get stressed or perish when subjected to pH extremes or fast pH shifts, even if the change occurs within a pH range that is typically tolerated. We found two pH controller products were available in the market of the south eastern Bangladesh (Table 9).

Table 9. The list of AMDC used as pH controller.

Trade name	Active ingredient	Doses/3-6 ft water	Sources
pH^{-R}	Organic Acid-15%, Gypsum-25%, Aluminum Silicate-60%	pH: 8-9, used: 6-8 kg/ 100 dec; pH: 9-9.5, used: 8-10 kg/ 100 dec; pH: above-9.5, used: 10-15 kg/ 100 dec	Univet Ltd.
Aqua Balance	Sodium humate, Polymerization aluminum potassium sulfate, enzyme	1 kg/ 100 dec	Ultimate (bd) Ltd.

3.2.9. AMDC used for oxygen supply

To boost the amount of dissolved oxygen in an aquaculture pond, many types of chemicals were applied in the farms of the study area. The most important active constituents in those chemicals are oxidizing agents such as hydrogen peroxide and sodium carbonates (Table 10).

Table 10. AMDC list of chemicals used for oxygen supply.

Trade name	Active ingredient	Doses/3-6 ft water	Sources
Oxymax	H_2O_2 10%	250-500 gm/ 100 dec (1 m deep water body)	Eon Animal Health
Aci-OX	Sodium carbonate, $H_2O_2$10%	General dose 300–400 gm/ 100 dec. In case of high deficiency 500–700 gm/100 dec	ACI Animal Health
Bio-OX	Sodium carbonate, H_2O_2	General dose 300–400 gm/ 100 dec. In case of high deficiency 500–700 gm/100 dec	ACI Animal Health
Oxy more	Sodium carbonate per-oxyhydrate	General dose 250–500 gm/ 100 dec. In case of high deficiency 750–1000 gm/100 dec	SK+F Pharmaceuticals Ltd.
Oxy top	Sodium Per carbonate	250-500 gm/ 100 dec	Nutrihealth Ltd.
Han-oxy	Sodium Per carbonate-14.5%	General dose 250–500 gm/ 100 dec. In case of high deficiency 750–1000 gm/ 100 dec	Ultimate (bd) Ltd.
First Oxy	Sodium Per carbonate	500–700 gm/100 dec	First Care Agro Ltd.
Oxy Aqua	Sodium Per carbonate	General dose 500–600 gm/ 100 dec. In case of high deficiency 1000–1200 gm/ 100 dec	PRAN Agro Business Ltd
Verno Ox	Sodium per carbonate	500 1000 gm/ 100 dec	Verno Bio-Solutions Ltd
Oxy Sos	Sodium per carbonate Peroxide	300 – 500 gm/ 100 dec	Advanced Agrotech (BD) Ltd
Oxy Rich	Sodium per carbonate	General dose 500 gm/ 100 dec. In case of high deficiency 1000 gm/ 100 dec	Opsonin Agrovet Division
Oxyren	Sodium per carbonate	1kg/100 dec	Renata Animal Health
O_2 marine	H_2O_2 10%	66–90 tablet/33 dec.	Organic pharmaceuticals ltd.
O-plus	O2 promoter (H_2O_2/Ca2O2)	500 gm/ 100 dec	Nature care Ltd.
Oxy gold	Sodium percarbonate	250 g/ 100 dec	Fishtech (BD) Limited
Oxy-plus	O2 promoter (H H_2O_2/Ca2O2)	500gm/ 100 dec	Penta Agrovet ltd.
Oxylife	Sodium carbonate 13%	400g/ 100 dec	Square AgroVet Division

Quick oxygen	Sodium percarbonate + free oxygen	In case of high deficiency 500 gm/ 100 dec in same water body	Organic pharmaceuticals Ltd.
Oxy-A	Sodium percarbonate	General dose 300–400 gm/100 dec. In case of high deficiency 500-700 gm/ 100 dec	The Acme Laboratories Ltd.
Oxy flow	$H_2O_2$10%	General dose 250–350 gm/100 dec. In case of high deficiency 500 gm/ 100 dec in same water body	Novartis Pharmaceuticals Ltd.
Oxygen plus	O2 promoter (H2O2/Ca2O2)	General dose 250–500 gm/100 dec. In case of high deficiency 750–1000 gm/ 100 dec	Avon Animal Health
Miracle O_2	Sodium Percarbonate-13.5%	General dose 200–250 gm/100 dec. In case of high deficiency 400–500 gm/ 100 dec	One Pharm Animal Health
V-Oxy TAB	Sodium carbonate peroxide	General dose 500–700 gm/100 dec. In case of high deficiency 1–1.2 kg/ 100 dec	VnF Agro Ltd.
Oxymix	Sodium carbonate peroxid-14%	General dose 250–500 gm/100 dec. In case of high deficiency 750–1 kg/ 100 dec	Save & Safe Agroscience Bangladesh
Oxy Pol	Sodium Percarbonate-13.5% + H_2O_2	250-500 / 100 dec	Catapol Bioscience Ltd.
Pure oxy	H_2O_2	1 kg/ 100 dec	Al Madina
Oxygrow	O2 promoter (H2O2/Ca2O2)	500 gm/ 100 dec	Century Agro Ltd.
Oxy gold	Sodium Percarbonate	250-500 / 100 dec	Fishtech (BD) Limited
Oxysun	Sodium peroxide, calcium peroxide, magnesium oxide	500 gm/ 100 dec	Rals Agro ltd., Bangladesh
Best oxygen	Sodium percarbonate	250–500 g/ 100 dec	Univet Ltd.
Fish care powder	Oxide of Ca, P, S, Mn, Mg, Cu, N	1 kg/33 dec.	S.S.S Agro care ltd.
Fish curepas	Oxide of Ca, P, S, Mn, Mg, Cu, N	1 kg/33 dec.	M.R. Food and Protein Industries
Oxywell	Sodium percarbonate, Tetra acetyl ethylene di amine	150-200g/4046.86m^2	First Care Agro Ltd.
Metoxy Tab	Sodium percarbonate: 99% and oxygen release: 13.60%	General dose 500 gm/ 100 dec. In case of high deficiency 1 kg/ 100 dec	Univet Ltd.
Oxy Ton	Sodium percarbonate-90% and others 10%	General dose 200–250 gm/ 100 dec. In case of high deficiency 400–500 gm/ 100 dec	Agrosol Bangladesh Company
U-Oxy	Sodium percarbonate-17%	General dose 250–500 gm/ 100 dec. In case of high deficiency 500–800 gm/100 dec	Uttara Tread bd

3.2.10. AMDC used as stress reducer

The available stress reducer were Ossi-C, Charger gel, Biomin Pondlife, Profs, Eskavit-C, Vitamin C –Soul, Energy plus, Osmosaline, Vita X-CK etc. The active ingredients of such medicines were mainly vitamin-C, betain, glucan, polyssceharides, beta-glucans, oxolinic acid bitaglucan (Table 11).

Table 11. AMDC used as stress reducer.

Trade name	Active ingredients	Doses/3-6 ft water	Sources
Glucovet Premix	Ascorbic acid (Vit-C)	1-2 g L-1	ACME Pharmaceuticals Co. Ltd.
Ossi-C	Oxolinic Acid, Beta glucan, Vitamin C	4-5g/ Kg feed	Fishtech (BD) Limited
Osmosaline	Betain	5-10g/100 Litre	Eon Animal Health
Cevit Aqua	L-ascorbic acid (Vit-C)	2-3 gm/ kg feed	Square AgroVet Division
Vita X-CK	Vit-C,K	1 gm/3 kg feed	Eon Animal Health
Eskavit-C	Vit-C 100%	1 g kg-1 feed	SK+F Pharmaceuticals Ltd.
Vitamin C –Soul	Vit-C 100%	3 g/Feed	Eon Animal Health
C-Aqua	Vit-C 100%	2-4 g/Feed	ACI Animal Health
Oralyte	Vita A with Electrolyte Premis	1 gm/ liter water	Opsonin Agrovet Division
Energy plus	Vita C + Glucose	1-2 gm/ liter water	ACI Animal Health
Vitmin C-Sol	Vita C-99%	2-3 gm/feed	Advanced Agrotech (BD) Ltd
Stress remover saline	$NaHCO_3$, Nacl, KCl, Vit A, $ZnSO_4$	0.5-1 gm/litter	VnF Agro Ltd.
Gluco-c Power	Vita C + Glucose	0.5-1 gm/ton	VnF Agro Ltd.
Vita Fast	Ascorbic acid	1-2 gm/ Feed	VnF Agro Ltd.
Verno C	Vita-C	0.5-1 gm/feed	Verno Bio-Solutions Ltd.
Renalyte-F	$NaHCO_3$, Nacl, KCl, Dextrose	3 kg/acere	Renata Animal Health
Aqualyte	$NaHCO_3$, Al_2O_3, CaO	3-5 kg/100 dec	Agrosol Bangladesh Company
Fish Saline	$NaHCO_3$, NaCl, KCl, Vitamin, Glucose	0.5-1 gm/litter	Uttara Tread bd.
Vitamix C Plus	Vitamin-C	1gm/litter	Uttara Tread bd.

3.2.11. AMDC used as growth promoter

All of the growth promoters are essential for the rapid increase of the fish population. Some of these chemicals, such as aqua boost, fish vita plus, Aqua savour, Eon fish grower, Aqua gel, Panvit aqua, Charger gel, Vitamin F aqua, Aci mix super fish, and others, help to improve the disease-prevention abilities of fish. Aqua boost is a type of growth promoter that is being used to boost the immune system of fish. Megavit aqua also helps to boost the hatching rate, and Aquamin is beneficial in the development of fishes' bones. Aqua savour and Grow quick both aid in the recovery of malnourished fishes as well as the improvement of their physical condition in general (Table 12).

Table 12. AMDC used as growth promoter.

Trade name	Active ingredients	Doses	Sources
Eon Fish Grower	Vitamin + Mineral premix	1.5-3 gm/kg feed	Eon Animal Health
Aqua savor	Amino acid premix	2–3 kg/MT feed	Eon Animal Health
Spa	Protein, Cholesterol 116arotenoid, Vit-D, Ca	10-15 ml/kg feed	Eon Animal Health
Fish Gel	Vitamin + Mineral premix	7–10 ml/kg feed	ACI Animal Health
Aquamin	Mineral premix + Herbal growth factor	2–4 ml/kg feed	ACI Animal Health
ACI Fish Premix	Vitamin + Mineral + Amnion acid+ Calcium and probiotics	1 kg/ ton feed	ACI Animal Health
Acimix super-fish	Vitamin, mineral + antioxydent	1 kg/ton Feed	ACI Animal Health
Krill Meal	Crude-Protein, Fat, Moisture, Ash, Fiber, CHO, Ca, and P	1-2 gm/ kg feed	ACI Animal Health
Vita Health Plus	Multivitamin, Nicotinamide, Biotin, Lysine, Foic acidETC	1ml/ kg feed	Ultimate (bd) Ltd.
Han-Vita	Vita-C, E, B1, K3, Sorbitol, Multienzyme	2-3 gm/ kg feed	Ultimate (bd) Ltd.
Aqua Live Care	Liver extract, Yeast Amini acid, protein, biotin, extract, sorbitol, vita-B_{12}	2-3 ml/ kg feed	Advanced Agrotech (BD) Ltd
Growth Gel	Essential vitamins, lysine, Methionine and herbs	7-10 ml/ kg feed	Advanced Agrotech (BD) Ltd
Multi Grow	Multivitamin, Multimineral, Biotin, Folic acid, Taaurine, Inositol	2-3 gm/ kg feed	Advanced Agrotech (BD) Ltd
Butamin	Cyanocobalamin, Methyl Hydroxybenzoat,	5 ml/ kg feed	Advanced Agrotech (BD) Ltd

	Methylethyl-phosphonic acid		
Growth Magic	Mutivitamin, Multienzyme, Multimineral, amino acid	3-5 gm/ kg feed	Agrosol Bangladesh Company
AVM- Aquamix	Mutivitamin, Multienzyme, Multimineral, amino acid	3-5 gm/ kg feed	Agrosol Bangladesh Company
Verno Vit Aqua	Vitamin Premix	2.5-5 kg/ton feed	Verno Bio-Splutions Ltd.
Saltose plus	Probiotics and Enzyme	250-500/ ton Feed	Opsonin Agrovet Division
Biomin Aqua Boost	Amino acid, Immune component,	3-5 gm/ kg feed	Reneta Animal Health
Fish Probiotics	*Bacillus subtilis*, Nitro fire, photosynthetic bacteria	1000-1500 gm/100 dec	VnF Agro Lid.
V-F. GEL	Vit $B_{12,}$ lysine, DL Methionine, Colin chloride, Biotin	0.5-10 ml/ kg feed	VnF Agro Lid.
Verno Boost	Growth promoter	1-2 gm/ kg feed	Verno Bio-Solutions Ltd.
Multisol-G	Multivitamins and Multiminerals	1-1.5 gm/ kg feed	Univet Ltd.
Chelamin Plus	Chelate Ca, Mn, K, Zn, Fe, Cu, Cr, Co	10 ml/ kg feed	Univet Ltd.
Panvit Aqua Liquid	Vit A, D_3, B_1, B_2,B_6, Nicotinamide and Vit-C	0.5-10 ml/ kg feed	Square AgroVet Division
Aqua GEL gel	Amino acids,ω_3 ω_6 fatty acid and Minerals	10-15 gm/ kg feed	Square AgroVet Division
Square Aquamix Powder	Vitamins, Amino acids, Minerals, Prebiotic and Antioxidant	1 gm/ kg feed	Square AgroVet Division
Provit gel	Vitamin A, B1,B2,B6, C, D, Niacinamide, Calcium pentothinate, Folic acid , Inositol, Lysine, Methionine, Protein hydrolyzate	10g/ kg feed	First care Agro. Ltd.
Fibosoel.	ß-Glucan and mannos polymer	200–300 g/MT feed	Eon Animal Health
Aqumin	Cu, Co, Mg, Fe, Zn, I, Ca, P, D, L. Mithiolin, L-lysin HCl	1gm/kg feed	ACI Animal Health
Grow Fast	High protein, Fat and Mineral	5-10% of body weight	ACI Animal Health
Ayumin powder	Mineral and herbs	5–10 kg/ton feed	ACI Animal Health
Eskavit	Vitamins, Minerals and Premix	2.5 kg /ton feed	SK+F Pharmaceuticals Ltd.
Aqua boost	Organic acid, ß-glucan	500 g/ ton feed	Novartis pharmaceuticals ltd.
Fish vita plus	Vitamin, mineral and amino acid supplement	200–300 ml/100 kg feed	Rals Agro ltd.
Grow fast	Vitamin, mineral and amino acid supplement	200–300 ml/100 kg feed	Rals Agro ltd.
Growmax	Vit + mineral + amino acid	2.5 kg/ton feed	Penta Agrovet ltd.
Megavit Aqua	Vitamin, mineral and amino acid supplement	100 g/100 kg feed	Novartis pharmaceuticals ltd.
Nature aqua GP	Vit + mineral + amino acid	2.5 kg/ton feed	Nature care ltd.
Orgavit aqua	Vitamin, mineral and amino acid supplement	100 g/100 kg feed	Organic pharmaceuticals ltd.
Safe Gurd	Vitamin, Enzyme and Probiotics	No recommendation found	SK+F Pharmaceuticals Ltd.
NutriGel	Vitamin, mineral and Probiotics	No recommendation found	SK+F Pharmaceuticals Ltd.
Esklina	100 % organic Sprolina	No recommendation found	SK+F Pharmaceuticals Ltd.
Acilina	100 % natural Sprolina	15-30 gm/ kg feed	ACI Animal Health
Rena Fish	Vit A, B, C, D3, E, K, Cu, Mn, Fe, Co etc.	1 Kg/ton feed	Reneta Animal Health
Charger Gel	1-3 D-Glucan, Polysaccharides, Btain, Beta Glucan	6-8 g/ kg feed	Fishtech (BD) Limited
Square Aquamix	Vitamin, Amino acid, Minaral, Probiotic,	1 g/kg feed	Square Pharmaceuticals Ltd.

	Anti oxydent etc.		
Vitamix F aqua	Vit + mineral + amino acid	2.5 kg/ton feed	The Acme laboratories Ltd.
Catamin	Vitamin and mineral	2-3 L/100 dec	Catapol Bioscience ltd.
Aqua Boost	Organic acid, Beta-Glucan	500 g/ ton feed	Novartis Pharmaceuticals Ltd.
Leabon aqua	*Saccharomyces cerivisiae*	3-5 gm/ kg feed	Reneta Animal Health
Power Gel	Cyanocobalamin, Methyle Hyydroxybenzoat	6-8 ml/ kg feed	Save & Safe Agroscience Bangladesh
Ultar Grow	Cyanocobalamin, Methyle Hyydroxybenzoat	5 ml/ kg feed	Ultimate (bd) Ltd.
Growth Master	Vitamin, Mineral, Biotin, Folic acid, B-Glucan & mannan	2-3 gm/ kg feed	Save & Safe Agroscience Bangladesh
Growmax Super	Vitamin, Mineral, Biotin, Folic acid, B-Glucan & mannan	1.5 gm/ kg feed	Save & Safe Agroscience Bangladesh
Grow Fast	Vitamin, mineral and amino acid supplement	200–300 ml/100 kg feed	Rals Agro
Promim Vit-Aqua	Vit A, Vit B, Vita-K_3 Complex, Vita-D, Vita-E, Vita-C, Co, I, Na, Zn, Cu, Ca, Fe, Mn Se, Lysine, colin chloride	200-300 gm/ 100 kg Feed	Promim Agro vet Industries
Provita Gel	Multivitamin, Ca, Folic acid, lysine, methionine	10 gm/ kg feed	First Care Agro Ltd.
U- Fish Growth	Vit A, Vit B, Vita-K_3 Complex, Vita-D, Vita-E, Vita-C, Co, I, Na, Zn, Cu, Ca, Fe, Mn Se, Lysine, colin chloride, Enzyme,biotin	2 gm/ kg feed	Uttara Tread bd.

3.2.12. Probiotics used in fish culture

Probiotics work by supplying nutrients, enzymes for improved digestion, regulating the immune system, and boosting the immunological response to harmful microorganisms. Lactic acid bacteria such as *Lactobacillus* sp., *Bacillus* sp., *Enterococcus* sp., and yeast *Saccharomyces cerevisiae* are the most often utilized probiotics in aquaculture. The study area included 21 probiotics items that were commonly used by farmers (Table 13).

Table 13. Probiotics used in freshwater aquaculture in south-eastern Bangladesh.

Trade name	Compositions	Purpose of use	Doses	Source
Profs	*Bacillus* sp. And *Padiococcus* sp.	Control vibriosis, luminescent bacteria	50-70 gm/33 dec	Eon Animal Health
Aqua photo	*Bacillus subtilis* and *Rhodoseudomonas*	Control unwanted gas, sediment and increase growth of plankton	50–70 ml/100 dec	ACI Animal Health
Navio Plus	*Bacillus subtilis* *Bacillus licheniformis, Bacillus megaterim,* *Lactobacillus Acidophilis* *Lactobacillus plantarum*	Increase growth rate and disease preventive power	1-3 gm/Feed	ACI Animal Health
Uni ecosense	*B. subtilis,* *B. licheniformis,* *B. polymyxa,* *B. pumuls,* *Thiobacillus deniftrificans,* *Aspergillus oryzae, Aspergillus niger, Pseudomonas denetrificans,* *Bacillus coagulans*		Fish:250-300g/4046.862m Shrimp:75-100 g/4046.862m	First care
Eco Marine	*Bacillius subtilis, B. pumilis, B. amylolichenifacions B. megaterium.*	Control vibriosis and luminescent bacteria	3–4 tablet/100 dec	Organic Pharmaceuticals Ltd.
Aqua Gold	*Rhodopseudomonas* sp.	Increase growth rate and disease preventive power	2 ml/100 dec	Organic Pharmaceuticals Ltd.

Aqua Magic	*Azobacter chorococcum* *Bacillus cereus* *Bacillus megaterium Bacillus subtilis Candida utilis* *Lactobacillus fermentus* *Lactobacillus planterum* *Rhodotorulla* sp.	Control unwanted gas, sediment and increase growth of plankton	5-6 kg/100 dec	Fish tech (BD) Limited
Aqua Star Grow Out	*Bacillus* sp *Lactobacillus* *Enterococcus* sp *Pedicocus* sp	Increase beneficial bacteria, increase feed attraction increase fish weight	3-5 gm/feed	Reneta Animal Health
Procon-PS	*Bacillus* sp., *Rhodococcus,* and *Rhodobacter*	Control unwanted gas, sediment and arrests the pathogens	5 L/hac (l m depth)	Rals Agro Ltd.
Super Biotic	*Bacillus* sp.	Reduce pathogenic bacteria in water	1–2 kg/ 100 dec	CP Aquaculture
Super PS	*Rodobacter* sp., *Rodococcus* sp.	Improve soil quality and reduce toxic gas from bottom	4–6 L/100 dec	CP Aquaculture
Pond care	*S. faecalis* and other bacteria	Inhibit pathogenic bacteria	50 gm/ 100 dec	SK+F Animal Health
Eco-Life	*Bacillus subtilis* *Bacillus megaterium* *Lactobacillus* Nitrosomonas sp Nitrobacter sp Yeast	Improve soil quality and inhibit pathogenic bacteria	200-300 gm/100 dec	Agrosol Bangladesh Company
First-Ecosafe	*Bacillus subtilis* *Bacillus Coagulans* *Bacillus megaterium* *Lactobacillus acidophil* *Aspergillus,* Nitrosomonas sp	Inhibit pathogenic bacteria like *Salmonella, Aero monas, E. Eoli, Vibrio*	200-250 gm/100 dec	First Care Agro Ltd.
PPM	Probiotics	Improve soil quality and reduce toxic gas from bottom	250 gm/100 dec	Verno Bio-Solutions Ltd.
Metprob	Nitrosomonas sp Nitrobacter sp *Bacillus subtilis* *Rhodobacter* *Padiococcus* sp. *Saccharomyces cerivisiae*	Reduce toxic gas from bottom, improve water quality	250-500 gm/100 dec	Univet Ltd.
Aqua Rich	*Bacillus subtilis,* Photosynthetic bacteria, Nitrifying bacteria Nitrobacteria sp Lactic acid bacteria, Yeast, Enzyme	Reduce toxic gas from bottom, control bloom, remove black Soil	500 gm/100 dec	Ultimate (bd) Ltd.
Delight Aqua	*Bacillus subtilis* Nitrobacteria, Nitrococcus Photosynthetic bacteria	Reduce toxic gas from bottom, control bloom, remove black Soil	600 gm/100 dec	Ultimate (bd) Ltd.
Aqua Life S	*Bacillus subtilis* *Bacillus megaterium* *Lactobacillus acidophil* Nitrosomonas sp Nitrobacter sp *Saccharomyces cerivisiae* Yeast	Reduce toxic gas from bottom, improve water quality, improved biological way	500 gm/100 dec	Save & Safe Agroscience Bangladesh
Aqua Clear S	*Bacillus subtilis* *Bacillus megaterium*	Reduce toxic gas from bottom, improve water	500 gm/100 dec	Advanced Agrotech (BD) Ltd

	Lactobacillus acidophil Nitrosomonas sp Nitrobacter sp *Saccharomyces cerivisiae*	quality, improved biological way		
Aqua Bac P	*Bacillus amyloliquefaciencs, Bacillus pumilus, $CaCO_3$,*	Reduce toxic gas from bottom, improve water quality, improved biological way	50-75/ 100 dec	Advanced Agrotech (BD) Ltd

3.2.13. Antibiotics for disease treatment

While only a few antibiotics have been approved for use in aquaculture, and precise data on their use is difficult to come by, at least two critically important antibiotics, tetracyclines and oxolinic acid, a third generation quinolone, are in routine use in Bangladesh and adjacent regions, respectively, to control specific diseases and bacterial infections in the aquaculture industry. Several antimicrobials, including antibiotics, were proposed for inclusion in fish feed regulations in 2011, and some of these were approved by the Bangladesh government in accordance with acceptable ranges of presence of these substances and the use of antibiotics, as well as the use of antibiotics in fish feed regulations in 2011. The present study found 19 antibiotics in the south eastern Bangladesh (Table 14).

Table 14. List of antibiotics for disease treatment in the study area.

Trade name	Active ingredients	Doses	Source
Oxy-D Vet	Oxytetracycline 20% Doxycycline 10%	5-10 g/Kg body wt. for 5-7 days	Eon Animal Health
EST-Vet	Erithromycine thiocyanate, Suiphadyazine, Trimethoprim	100-150 gm/1000 kg body wt. for 3-5 days	Eon Animal Health
Ablaze	Vitamin, Mineral, Antimicrobial agents	150-200 gm/ 1000 kg body wt.	Eon Animal Health
Bactitab	Oxytetracycline 20%	5 gm/kg body weight 5–7 days	ACI Animal Health
Acimox (vet) powder	Amoxicillin trihydrate	1 gm/1 kg feed	ACI Animal Health
Cotrim-vet	Sulphamethoxazole + trimethoprim	0.5 mg/kg body weight	Square AgroVet Division.
Contrim (vet) bolus	Cotrimoxazole	1 bolus/10–12 kg body weight	Square AgroVet Division
Otetra (vet) powder 50	Oxytetracycline	Mixed with feed; 11–16 gm/100 kg body weight	Square AgroVet Division
Oxin WS	Oxytetracycline 20%	50 mg/kg body weight	Navana pharmaceuticals ltd.
Oxysentin 20%	Oxytetracycline HCL BP	50–100 gm/100 kg feed, 5–7 days (for treatment)	Novartis pharmaceuticals ltd.
Ranamox	Amoxicillin trihydrate	28–40 gm/100 bd of fish, 10 days continuously	Renata Animal Health.
Renamycin	Oxytetracycline	28–42 gm/100 kg feed, 10 days	Renata Animal Health
Sulphatrim	Sulphadiazine	50 gm/kg body weight, 5–7 days	Square AgroVet Division
Aquamycine	Oxytetracycline HCL 25%	1-2 g/Kg feed for 5-7 days	ACI Animal Health
Chlorsteclin	Chlortetracycline	200–300 gm/100 kg feed (5–7 days)	Novartis pharmaceuticals ltd.
Amoxifish	Amoxicillin trihydrate	3-5 gm/kg feed	Fish tech
Orgacycline 15%	Chlortetracycline	200–300 gm/100 kg feed 5–7 days	Organic pharmaceuticals ltd.
Fish cure	Chlortetracycline HCL	500 gm/1000 kg feed (3–5 days)	Rals agro ltd.
Argulex	Trichlorofon 40%	12-13 ml/dec	Eon Animal Health

4. Discussion

Aquaculture generates a great deal of financial activity and transaction in the south-western portion of Bangladesh, and this is mostly owing to both the intensity and the extent of the nature of the aquaculture activity in this region. According to a number of prior studies, aquaculture in these specific locations might contribute to the regional and national demand for animal protein, as well as providing financial assistance to local farmers and, ultimately, to the gross domestic product (GDP) (Al-Asif *et al*., 2021; Ullah *et al*., 2020b). While the aquaculture industry has a direct relationship with the social and economic growth of an area, a small-scale and healthy farm may create enough money to support a nuclear family in a comfortable manner (Adhikary *et al*., 2018c; Adhikary *et al*., 2018a, 2018b; Al-Asif *et al*., 2015; Al-Asif and Habib, 2018; Ali *et al*., 2016; Hossain *et al*., 2017, 2015; Islam *et al*., 2017, 2014; Rahman *et al*., 2017a; Razeim *et al*., 2017; Sharif *et al*., 2015; Vaumik *et al*., 2017).

Approximately 33 businesses were found to be either manufacturing or selling aqua medicines, drugs, and chemicals (AMDC) items aimed at freshwater aquaculture in the south-eastern portion of Bangladesh, according to the results of the present study. However, study of Rahman *et al*. (2017b) suggested 24 companies were established and continuing their business in only Cumilla region and 30 nationwide companies were reported by the study of Al-Asif *et al*. (2021).

In the booklet of company (provided by the company), they gave in-depth information on the objectives, doses, duration, and mode of application of the substances they were using. The usage and effectiveness of several of the items, on the other hand, were seen differently by farmers. There have been reports of certain businesses providing technical help to the farmers (Al-Asif *et al*., 2021). As a result, the farmers are subjected to significant pressure from commercial enterprises to utilize a diverse range of products on their fields.

The present study revealed 330 AMDC products were available in the three districts of south eastern region of Bangladesh, while a nationwide investigation from 2011-2020 revealed 1484 items of products from different generic and business names are available around Bangladesh (Al-Asif *et al*., 2021), which is relevant with the present study.

Several kinds of predatory fish may get access to aquaculture farms via water sources or by being introduced to the farm with seed that has been brought in from outside (Nunny, 2020). The use of water management techniques in farms, such as periodic draining and preparations for the introduction of new stock, provides possibilities for farmers to exert a fair degree of control over predatory fish in their fields which might be costly for the farmers (Biswas *et al*., 2018; Ledesma, 2019; Otieno, 2019). It is relatively simple to implement control measures in outdoor nursery ponds, where the post-larvae and fry are vulnerable to predation not only by predatory fish, but also by insect larvae, notonectids, and other amphibians such as frogs. For example, spreading oil emulsions to prevent aerial breathing of insect larvae or fencing to prevent entry of frogs are both relatively simple and effective measures. Controlling avian and mammalian predators is more challenging than controlling rodents (Mogi, 2007; Ram Kumar, 2006).

Ectoparasites, which include single-celled protozoa, multi-celled trematodes, crustaceans, and arthropods, are a common infectious agent in freshwater fish and are found in a broad variety of environments. Ectoparasites are a kind of infectious pathogen that may infect freshwater fish and other aquatic organisms (Bruno *et al*., 2006; Iyaji and Eyo, 2009). There were many insecticides used on arugulas in the study area, including Engreb, Paratics, and Acemec 1 percent Oral Solution, among other things.

The present study suggested that various sort of pond preparation chemical and materials were used in the south eastern part of Bangladesh, including zeolite, lime and sometimes changes in water in a proper manner. While the study of Adhikary *et al*. (2018c), Chowdhury *et al*. (2015), Ullah *et al*. (2020) reported that lime, zeolite, fish toxin, insecticides and different fertilizers were used for the preparation and water quality management in Jashore, Sylhet and Noakhali regions respectively.

The usage of Geotox, Zeolite, Zeocare, lime, Mega Zeo Plus, Bio Aqua, Aquanone, and Zeo prime for pond preparation and water quality management by various farmers in Bangladesh was reported by Rahman *et al*. (2017b). When it came to fish aquaculture in Bangladesh, lime was by far the most frequently utilised chemical.

Plankton is an essential food source for fish and a good indication of the overall productivity of a body of water (Akter *et al*., 2018; Siddika *et al*., 2013). In a water body, the qualitative and quantitative abundance of phytoplankton indicates whether the water body is oligotrophic or eutrophic, and therefore the productivity of the water body (Akter *et al*., 2018; Sipaúba-Tavares *et al*., 2011). A comprehensive understanding of phytoplankton quantity and quality in connection to environmental circumstances, both in time and space, has become a requirement for the production of high-quality fish (Chukwu and Afolabi, 2018; Hossain *et al*., 2019). The existence of zooplankton production is largely dependent on the availability of primary production (Anton-Pardo and Adámek, 2015; Bhaumik *et al*., 2006; Korhonen *et al*., 2011). Many plankton producers' chemicals

were found in the study area while most of them are traditional fertilizers which are used in the agricultural set up.

Lime is also used for common fish disease. Formalin apparently reacts with ammonia to form hexamethylene-triamine and possibly formamide, a toxic substance to aquatic ecosystem. Other researchers have also reported use of such chemicals in pond culture and in hatchery operations. The 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 as also observed in the present survey.

A large number of algal blooms occur in aquaculture ponds, and they are frequently catastrophic. In fish ponds, nutrient enrichment caused by the addition of fertilizers and additional feeding results in eutrophication, which is characterized by the development of thick algal blooms on a regular basis (Padmavathi and Prasad, 2007; Rodgers, 2008; Trottet *et al*., 2021). Removing the phytoplankton bloom is one of the challenges in aquaculture setup due to it works as primary producers in the pond. The farmers use some bloom cleaner materials including NO algae, Kill Alage and other trade name products, while urea and copper is one of the major components of the chemicals.

The use of disinfectants in both manufacturing and processing facilities is commonplace since they are effective at killing bacteria, viruses, and other pests (Ali *et al*., 2014; Kasai *et al*., 2002). There are a variety of chemicals that are extensively utilized in the aquaculture sector as disinfectants (Al-Asif *et al*., 2021; Chowdhury *et al*., 2015; Rahman *et al*., 2017). These chemicals are regularly employed in the majority of fish and shrimp hatcheries, grow-out facilities, and processing facilities to eliminate bacteria, viruses, and other pests that may negatively affect production. Depending on the nation, laws regulating the use of disinfectants may vary from being very easy to being quite difficult to understand (Chen *et al*., 2018; Kim *et al*., 2008; Pomaranski and Soto, 2020). The current study revealed Timsen and Pahonil were the most popular disinfectant in the aquaculture setup in the south eastern Bangladesh.

Waterborne creatures are particularly vulnerable to hydrogen sulphide (H_2S) and ammonia (NH_3-N), which are poisonous gases in general. Some bacteria use the uneaten feed and organic debris on the pond bottom to produce H_2S gas, which gives the pond a rotten egg smell when it is under anaerobic conditions (Rahman *et al*., 2015; Sumantri *et al*., 2020). The study found some toxic gas reducers products along with gas removal probiotics were fairly use in the aquaculture setup. In most of the products the extract of *Yucca schidigera* plants were the primary ingredients (Dawood *et al*., 2021; Santacruz-Reyes and Chien, 2012; Yu *et al*., 2015).

In the fish and shrimp farming industries, aquaculturists are unaware of the magnitude of economic losses that could be avoided if pH levels were maintained at levels that are safe for fish. Controlling pH in water, in conjunction with the adoption of management practices to maintain pH levels at levels that are safe for fish, could help to mitigate these losses (Africa *et al*., 2017; Grøttum *et al*., 1997; Pote *et al*., 1990). The study area comprised of two pH controller chemical products which might helpful to buffer the pH of aquaculture setup.

Oxygenating agent are useful while the oxygen level of an aquaculture setup become depleted in a dangerous level (Chowdhury *et al*., 2015). In the study area we found several companies oxygenating chemical agents which were readily available in the market; while the most of the ingredients of the oxygenating agents are similar but they do marketing with different brand or trade name, including ACI OX, BIO OX, etc.

Vitamins and minerals, particularly vitamin C, have been shown to be stress reducers in aquaculture settings. While certain medications are extremely helpful in acting as growth promoters, farmers that want to obtain their final products as quickly as possible add various minerals and vitamins to the feed, including different vitamins and minerals premix, in order to speed up the process (Al-Asif *et al*., 2021; Chowdhury *et al*., 2015; Hasan *et al*., 2015; Rahman *et al*., 2017b). The current study revealed that, the highest number of AMDC products were growth promoter (total 59 items; 17.88%) (Refer to, Figure 2).

Probiotics are microbial organisms and yeast preparations that have positive effects on the host body's nutrition consumption, digestion, development, and immunological response by encouraging the growth of beneficial bacteria and yeast (Hai, 2015; Martínez Cruz *et al*., 2012; Verschuere *et al*., 2000; Zorriehzahra *et al*., 2016). *Bacillus* spp., which produce spores and are Gram positive, are the primary components of the vast majority of probiotics used in fish farming (Fijan, 2014; Hlordzi *et al*., 2020). The use of probiotics as an environmentally acceptable alternative to antibiotics and other medicines has found widespread use in the treatment of illness in aquaculture (Farzanfar, 2006; Jahangiri and Esteban, 2018). A broad variety of beneficial bacteria strains were found in the probiotic formulations. These included *Bacillus* sp., *Lactobacillus* sp., *Nitrosomonas* sp., *Aspergillus* sp., *Pseudomonas* sp., *Clostridium* sp., *Rhodococcus* sp., *Rhodobacter* sp., and *Saccharomyces cerevisiae* (Rahman *et al*., 2017b; Shefat, 2018). Among others the validity and quality of goods containing various combinations of the probiotic organisms listed above were not confirmed despite a large number of such

products being available on the market and in great demand. But such goods were in great demand across all aquaculture zones, suggesting that they were successful, despite the fact that their usefulness has not yet been scientifically shown.

As a result of the fact that only a few antibiotics have been approved for use in aquaculture and that precise data on their use is difficult to come by, at least two critically important antibiotics, such as the tetracyclines and oxolinic acid (a third generation quinolone), are now being used in routine practise in Bangladesh to control specific diseases and bacterial infections in the aquaculture industry, respectively (Al-Asif *et al*., 2021). Study of Lulijwa et al. (2020) and Rahman *et al*. (2017b) both reported at least 19 antibiotics were available in Bangladesh and Cumilla respectively. While the present study support the previous findings with the report of 19 antibiotics from the south eastern region of Bangladesh, comprising three popular aquaculture regions, Chandpur, Cumilla and Feni.

5. Conclusions

The aquaculture medicine drugs and chemicals are widely used by the farmers of south eastern Bangladesh, while the adverse effects of antimicrobial agents are simply neglected by the farmers or other stakeholders. Bioremediation, probiotics, immune-stimulants, immunization, and alternative therapeutics are examples of alternatives that may be utilized instead of antibiotics. For mitigating the harmful effects of antibiotics usage in aquaculture; policymakers, researchers, and scientists should collaborate in order to solve the problems surrounding some adverse AMDC products use in this industry.

Conflict of interest

None to declare.

Authors' contribution

Conceptualization and execution of study: Amir Hossain and Abdulla-Al-Asif; methods: Amir Hossain and Abdulla-Al-Asif; data collection: Amir Hossain; statistics and presentation: Abdulla-Al-Asif; Map preparation: Abdulla-Al-Asif; writing, original-draft preparation: Amir Hossain and Abdulla-Al-Asif; writing, review and editing: Amir Hossain, Saiful Islam, Abdulla-Al-Asif and Hafzur Rahman. All authors have read and agreed to the published version of the manuscript.

References

Adhikary RK, S Kar, A Faruk, A Hossain, MNM Bhuiyan and A Al-Asif, 2018a. Contribution of aquaculture on livelihood development of fish farmer at Noakhali, Bangladesh. Asian-Australasian J. Biosci. Biotechnol., 3: 106–121.

Adhikary RK, M Rahman and A Al-Asif, 2018b. Present status of aqua-medicines used in aquaculture at Jessore sadar upazila, Bangladesh. Asian J. Med. Biol. Res., 4: 288–297.

Adhikary MR, A Rahman, A Al-Asif and RK Adhikary, 2018c. Socio-economic status of fish retailers in Jashore sadar, Bangladesh. Asian-Australasian J. Food Saf. Secur., 2: 100–108.

Africa ADM, JCCA Aguilar, CMS Lim, PAA Pacheco and SEC Rodrin, 2017. Automated aquaculture system that regulates pH, temperature and ammonia. HNICEM 2017 - 9th Int. Conf. Humanoid, Nanotechnology, Inf. Technol. Commun. Control. Environ. Manag., 2018: 1–6.

AftabUddin S, MG Hussain, M Abdullah Al, P Failler and BM Drakeford, 2021. On the potential and constraints of mariculture development in Bangladesh. Aquac. Int., 29: 575–593.

Ahmed GU, M Dhar, MNA Khan and JS Choi, 2007. Investigation of diseases of Thai koi, *Anabas testudineus* (BLOCH) from farming conditions in winter. J. Life Sci., 17: 1309-1314.

Akter S, MM Rahman, A Faruk, MNM Bhuiyan, A Hossain and A Al-Asif, 2018. Qualitative and quantitative analysis of phytoplankton in culture pond of Noakhali district, Bangladesh. Int. J. Fish. Aquat. Stud., 6: 371–375.

Al-Asif A and MAB Habib, 2018. Socio-economic condition of fish farmers of Jhikargachha upazila in Jessore district, Bangladesh. Asian J. Med. Biol. Res., 3: 462–475.

Al-Asif A, A Hossain, H Hamli, S Islam and SL Kabir, 2021. Research trends of aqua medicines, drugs and chemicals (AMDC) in Bangladesh: the last decade's (2011-2020) story to tell. Asian J. Med. Biol. Res., 7: 90–106.

Al-Asif A, MA Samad, MH Rahman, MA Farid, SM Yeasmin and BMS Rahman, 2015. Socio-economic condition of fish fry and fingerling traders in greater Jessore region, Bangladesh. Int. J. Fish. Aquat. Stud., 2: 290–293.

Alam MM and MM Haque, 2021. Presence of antibacterial substances, nitrofuran metabolites and other chemicals in farmed pangasius and tilapia in Bangladesh: Probabilistic health risk assessment. Toxicol. Reports, 8: 248–257.

Ali MM, A Al-Asif, MAI Shabuj, S Vaumik, MA Zafar and BMN Sharif, 2016. Status of polyculture *Pangasius hypophthalmus* with carps in Jhikargacha Upazila of Jessore district , Bangladesh. Int. J. Fish. Aquat. Stud., 4: 423–430.

Ali MM, MA Rahman, MB Hossain and MZ Rahman, 2014. Aquaculture drugs used for fish and shellfish health management in the southwestern Bangladesh. Asian J. Biol. Sci., 7: 225–232.

Anton-Pardo M and Z Adámek, 2015. The role of zooplankton as food in carp pond farming: A review. J. Appl. Ichthyol., 31: 7–14.

Assefa A and F Abunna, 2018. Maintenance of fish health in aquaculture: Review of epidemiological approaches for prevention and control of infectious disease of fish. Vet. Med. Int., 5432497: 1-10.

Bayazid Y, 2016. The daudkandi model of community floodplain aquaculture in Bangladesh: A case for Ostrom's design principles. Int. J. Commons, 10: 854–877.

Bhaumik U, P Das and T Paria, 2006. Impact of plankton structure on primary productivity in two beels of West Bengal, India. Bangladesh J. Fish. Res., 10: 1–11.

Biswas C, MMM Hossain, A Al-Asif, B Sarker, MM Billah and MA Ali, 2018. Culture strategies, diseases and their mitigations in mono-sex Nile tilapia farming in Jessore sadar region, Bangladesh. Asian-Australasian J. Biosci. Biotechnol., 3: 190–200.

Bostock J, B McAndrew, R Richards, K Jauncey, T Telfer, K Lorenzen, D Little, L Ross, N Handisyde, I Gatward and R Corner, 2010. Aquaculture: Global status and trends. Philos. Trans. R. Soc. B Biol. Sci., 365: 2897–2912.

Boyd CE, LR D'Abramo, BD Glencross, DC Huyben, LM Juarez, GS Lockwood, AA McNevin, AGJ Tacon, F Teletchea, JR Tomasso, CS Tucker and WC Valenti, 2020. Achieving sustainable aquaculture: Historical and current perspectives and future needs and challenges. J. World Aquac. Soc., 51: 578–633.

Bruno DW, B Nowak and DG Elliott, 2006. Guide to the identification of fish protozoan and metazoan parasites in stained tissue sections. Dis. Aquat. Organ., 70: 1–36.

Cabello FC, HP Godfrey, A Tomova, L Ivanova, H Dölz, A Millanao and AH Buschmann, 2013. Antimicrobial use in aquaculture re-examined: Its relevance to antimicrobial resistance and to animal and human health. Environ. Microbiol., 15: 1917–1942.

Chen X, C Lai, Y Wang, L Wei and Q Zhong, 2018. Disinfection effect of povidone-iodine in aquaculture water of swamp eel (*Monopterus albus*). PeerJ, 2018: 1–13.

Chowdhury AA, MS Uddin, S Vaumik and A Al-Asif, 2015. Aqua drugs and chemicals used in aquaculture of Zakigonj upazilla, Sylhet. Asian J. Med. Biol. Res., 1: 336–349.

Chukwu MN and ES Afolabi, 2018. Phytoplankton abundance and distribution of fish earthen ponds in Lagos, Nigeria. J. Appl. Sci. Environ. Manag., 21: 1245.

Dawood MAO, MS Gewaily, MN Monier, EM Younis, H Van Doan and H Sewilam, 2021. The regulatory roles of yucca extract on the growth rate, hepato-renal function, histopathological alterations, and immune-related genes in common carp exposed with acute ammonia stress. Aquaculture, 534: 736287.

Diana JS, HS Egna, T Chopin, MS Peterson, L Cao, R Pomeroy, M Verdegem, WT Slack, MG Bondad-Reantaso and F Cabello, 2013. Responsible aquaculture in 2050: Valuing local conditions and human innovations will be key to success. Bioscience, 63: 255–262.

Faruk M, H Shorna and I Anka, 2021. Use and impact of veterinary drugs, antimicrobials, and supplements in fish health management. J. Adv. Vet. Anim. Res., 8: 36–43.

Faruk MAR, MJ Alam, MMR Sarker and MB Kabir, 2004. Status of fish disease and health management practices in rural freshwater aquaculture of Bangladesh. Pakistan J. Biol. Sci., 7: 2092–2098.

Farzanfar A, 2006. The use of probiotics in shrimp aquaculture. FEMS Immunol. Med. Microbiol., 48: 149–158.

Fijan S, 2014. Microorganisms with claimed probiotic properties: An overview of recent literature. Int. J. Environ. Res. Public Health, 11: 4745–4767.

Froehlich HE, CA Runge, RR Gentry, SD Gaines and BS Halpern, 2018. Comparative terrestrial feed and land use of an aquaculture-dominant world. Proc. Natl. Acad. Sci. U. S. A., 115: 5295–5300.

Grøttum JA, M Staurnes and T Sigholt, 1997. Effect of oxygenation, aeration and pH control on water quality and survival of turbot, *Scophthalmus maximus* (L.), kept at high densities during transport. Aquac. Res., 28: 159–164.

Hai NV, 2015. The use of probiotics in aquaculture. J. Appl. Microbiol. 119: 917–935.

Hasan M, M Faruk, I Anka and M Azad, 2014. Investigation on fish health and diseases in rural pond aquaculture in three districts of Bangladesh. J. Bangladesh Agric. Univ., 11: 377–384.

Hasan MT, GU Ahmed, MM Rahman and MN Alam, 2015. Study on the effect of aquaculture-drugs and chemicals on health and production of prawn (*Macrobrachium rosenbergii*) in Narail, Bangladesh. Asian J. Med. Biol. Res., 1: 89–94.

Hinchliffe S, A Butcher and MM Rahman, 2018. The AMR problem: demanding economies, biological margins, and co-producing alternative strategies. Palgrave Commun., 4: 142.

Hinchliffe S, A Butcher, MM Rahman, J Guilder, C Tyler and D Verner-Jeffreys, 2021. Production without medicalisation: Risk practices and disease in Bangladesh aquaculture. Geogr. J., 187: 39–50.

Hlordzi V, FKA Kuebutornye, G Afriyie, ED Abarike, Y Lu, S Chi and MA Anokyewaa, 2020. The use of Bacillus species in maintenance of water quality in aquaculture: A review. Aquac. Reports, 18: 100503.

Hoque R, SM Ahmed, N Naher, MA Islam, EK Rousham, BZ Islam and S Hassan, 2020. Tackling antimicrobial resistance in Bangladesh: A scoping review of policy and practice in human, animal and environment sectors. Plos One, 15: 1–22.

Hossain A, MAR Hossain, A Al-Asif, S Ahmed and A Satter, 2017. Fish fermentation in Lalpur, Brahmanbaria district : ecological implication and value chain analysis. Asian-Australasian J. Biosci. Biotechnol., 2: 159–172.

Hossain AM, A Al-Asif, AM Zafar, TM Hossain, SM Alam and AM Islam, 2015. Marketing of fish and fishery products in Dinajpur and livelihoods of the fish retailers. Int. J. Fish. Aquat. Stud., 3: 86–92.

Hossain MB, SMN Amin, M Shamsuddin, MH Minar, 2013. Use of aqua-chemicals in the hatcheries and fish farms of greater Noakhali, Bangladesh. Asian J. Anim. Vet. Adv., 8: 401–408.

Hossain MI, MS Rahman, AKMR Amin, SI Ahmed and M Shahjahan, 2019. Effects of sumithion on growth and production of phytoplankton and zooplankton in aquaculture ponds. Iran. J. Fish. Sci., 18: 307–318.

Hossain MK, MS Haq, BK Chawkraborty, MT Hasan and SK Mazumder, 2014. Present status of aqua-medicines used for fish culture at Shantahar and Adamdighi of Bogra district, Bangladesh. IOSR J. Environ. Sci. Toxicol. Food Technol., 8: 37–42.

Islam FK, A Al-Asif, M Ahmed, MS Islam, B Sarker, MA Zafar and M Rahman, 2017. Performances of resource poor households in aquaculture practices in sadar upazila, Meherpur, Bangladesh. Int. J. Fish. Aquat. Stud., 5: 281–288.

Islam MA, A Al-Asif, MA Samad, BMS Rahman, MH Rahman, A Nima and SM Yeasmin, 2014. Socio-economic conditions of the fish farmers in Jessore, Bangladesh. Int. J. Business, Soc. Sci. Res., 2: 153–160.

Islam MM, A Barman, GK Kundu, MA Kabir and B Paul, 2019. Vulnerability of inland and coastal aquaculture to climate change: Evidence from a developing country. Aquac. Fish., 4: 183–189.

Iyaji F and J Eyo, 2009. Parasites and their freshwater fish host. Bio-Research, 6, 328–338.

Jahangiri L and MÁ Esteban, 2018. Administration of probiotics in the water in finfish aquaculture systems: A review. Fishes, 3: 1–13.

Kasai H, M Yoshimizu and Y Ezura, 2002. Disinfection of water for aquaculture. Fish. Sci., 68: 821–824.

Khan MA, R Begum, R Nielsen and A Hoff, 2021. Production risk, technical efficiency, and input use nexus: Lessons from Bangladesh aquaculture. J. World Aquac. Soc., 52: 57–72.

Kim SR, KH Park, D Kim, SJ Jung, SY Kang and MJ Oh, 2008. Antimicrobial effects of chemical disinfectants on fish pathogenic bacteria. Food Sci. Biotechnol., 17: 971–975.

Korhonen JJ, J Wang and J Soininen, 2011. Productivity-diversity relationships in lake plankton communities. Plos One, 6: e22041.

Kotob MH, S Menanteau-Ledouble, G Kumar, M Abdelzaher and M El-Matbouli, 2016. The impact of co-infections on fish: a review. Vet. Res., 47: 1–12.

Lafferty KD, CD Harvell, JM Conrad, CS Friedman, ML Kent, AM Kuris, EN Powell, D Rondeau and SM Saksida, 2015. Infectious diseases affect marine fisheries and aquaculture economics. Ann. Rev. Mar. Sci., 7: 471–496.

Ledesma RG, 2019. Effectiveness of predator control set-up for aquatic pest control in earthen ponds for extensive culture of *Penaeus monodon* (Fabricius, 1798). Philipp. J. Fish., 26: 61–65.

Leung TLF and AE Bates, 2013. More rapid and severe disease outbreaks for aquaculture at the tropics: Implications for food security. J. Appl. Ecol., 50: 215–222.

Liu C, L Tan, L Zhang, W Tian and L Ma, 2021. A review of the distribution of antibiotics in water in different regions of China and current antibiotic degradation pathways. Front. Environ. Sci., 9: 1–24.

Lulijwa R, EJ Rupia and AC Alfaro, 2020. Antibiotic use in aquaculture, policies and regulation, health and environmental risks: a review of the top 15 major producers. Rev. Aquac., 12: 640–663.

Majumder B, MGA Sarker, MH Khan and MBR Chowdhury, 2001. Incidence of ulcer type of disease in wild fishes of Bangladesh. Bangladesh J. Fish. Res., 5: 163–168.

Martínez Cruz P, AL Ibáñez, OAH Monroy and HCS Ramírez, 2012. Use of probiotics in aquaculture. ISRN Microbiol., 2012: 1–13.

Mogi M, 2007. Insects and other invertibrate predators. J. Am. Mosq. Control Assoc., 23: 93–109.

Naylor RL, RW Hardy, AH Buschmann, SR Bush, L Cao, DH Klinger, DC Little, J Lubchenco, SE Shumway and M Troell, 2021. A 20-year retrospective review of global aquaculture. Nature, 591: 551–563.

Neela FA, MSTNA Banu, MA Rahman, MF Alam and MH Rahman, 2015. Occurrence of antibiotic resistant bacteria in pond water associated with integrated poultry-fish farming in Bangladesh. Sains Malaysiana, 44: 371–377.

Nunny L, 2020. Animal welfare in predator control: Lessons from land and sea. How the management of terrestrial and marine mammals impacts wild animal welfare in human–wildlife conflict scenarios in Europe. Animals, 10: 1–24.

Otieno NE, 2019. Economic impact of predatory piscivorous birds on small-scale aquaculture farms in Kenya. Aquac. Reports, 15: 100220.

Padmavathi P and MKD Prasad, 2007. Studies on algal bloom disasters in carp culture ponds. J. Morphol. Sci., 24: 32–43.

Pomaranski EK and E Soto, 2020. The formation, persistence, and resistance to disinfectant of the *Erysipelothrix piscisicarius* biofilm. J. Aquat. Anim. Health, 32: 44–49.

Pote JW, TP Cathcart and PN Deliman, 1990. Control of high pH in aquacultural ponds. Aquac. Eng., 9: 175–186.

Pravakar P, BS Sarker, M Rahman and MB Hossain, 2013. Present status of fish farming and livelihood of fish farmers in Shahrasti Upazila of Chandpur district, Bangladesh. Am. J. Agric. Environ. Sci., 13: 391–397.

Rahman H, JA Mirza, A Hossain, A Al-Asif, E Haq, P Chwakravorty and M Rahman, 2017a. Economics of fish production in paddy fields in Bangladesh. Asian J. Med. Biol. Res., 3: 379–390.

Rahman ML, M Shahjahan and N Ahmed, 2021. Tilapia farming in Bangladesh: Adaptation to climate change. Sustain., 13: 1–20.

Rahman MM, MMM Alam, SMI Khalil, SM Bari and MM Rashid, 2015. Status of chemicals and aqua drugs used in freshwater aquaculture in north-eastern Bangladesh. J. Sylhet Agric. Univ., 2: 247–256.

Rahman MZ, A Khatun, MI Kholil and MMM Hossain, 2017b. Aqua drugs and chemicals used in fish farms of Comilla regions. J. Entomol. Zool. Stud., 5: 2462–2473.

Rahman S, S Mondal and A Hossain, 2019. Agrochemicals used in freshwater aquaculture in Jhenaidah district, Bangladesh. Asian-Australasian J. Food Saf. Secur., 3: 63–76.

Ram Kumar JSH, 2006. Larvicidal efficiency of aquatic predators: A perspective for mosquito biocontrol. Zool. Stud., 45: 447–466.

Rasul MG and BC Majumdar, 2017. Abuse of antibiotics in aquaculture and it's effects on human, aquatic animal and environment. Saudi J. Life Sci., 2: 81–88.

Razeim MA, MG Farouque, MA Sarker, A Al-Asif and M Ahmed, 2017. Attitude of farmers towards Pangas farming for their livelihood improvement. Asian-Australasian J. Biosci. Biotechnol., 2: 106–119.

Reverter M, S Sarter, D Caruso, JC Avarre, M Combe, E Pepey, L Pouyaud, S Vega-Heredía, H de Verdal and RE Gozlan, 2020. Aquaculture at the crossroads of global warming and antimicrobial resistance. Nat. Commun., 11: 1–8.

Rodgers JH, 2008. Algal toxins in pond aquaculture. South. Reg. Aquac. Cent., 4605, 7.

Santacruz-Reyes RA and YH Chien, 2012. The potential of *Yucca schidigera* extract to reduce the ammonia pollution from shrimp farming. Bioresour. Technol., 113: 311–314.

Schar D, C Zhao, Y Wang, DGJ Larsson, M Gilbert and TP Van Boeckel, 2021. Twenty-year trends in antimicrobial resistance from aquaculture and fisheries in Asia. Nat. Commun., 12: 6–15.

Shabuj MAI, T Bairagi, Al A -Asif, O Faruq, MR Bari and MS Neowajh, 2016. Shrimp disease investigation and culture strategies in Bagerhat district, Bangladesh. Asian J. Med. Biol. Res., 1: 545–552.

Shamsuzzaman MM and TK Biswas, 2012. Aqua chemicals in shrimp farm: A study from south-west coast of Bangladesh. Egypt. J. Aquat. Res., 38: 275–285.

Shamsuzzaman MM, MMM Hoque, SJ Mitu, AF Ahamad and MS Bhyuian, 2020. The economic contribution of fish and fish trade in Bangladesh. Aquac. Fish., 5: 174–181.

Shamsuzzaman MM, MM Islam, Tania NJ, AMM Abdullah, PP Barman and X Xu, 2017. Fisheries resources of Bangladesh: Present status and future direction. Aquac. Fish., 2: 145–156.

Sharif BMN and A Al-Asif, 2015. Present status of fish hatchlings and fry production management in greater

Jessore, Bangladesh. Int. J. Fish. Aquat. Stud., 2: 123–127.
Sharif BN, A Al-Asif, S Vaumik, MA Zafar, MM Islam and MA Samad, 2015. Socio-economic condition of fish farmer and trader at the village of Pitamborpur in Chaugachha Upazilla in Jessore, Bangladesh. Int. J. Fish. Aquat. Stud., 3: 212–217.
Sharker MR, KR Sumi, MJ Alam, MM Rahman, Z Ferdous, MM Ali and MR Chaklader, 2014. Drugs and chemicals used in aquaculture activities for fish health management in the coastal region of Bangladesh. Int. J. Life Sci. Biotechnol. Pharma Res., 3: 49–58.
Shefat SHT, 2018. Use of probiotics in shrimp aquaculture in Bangladesh. Acta Sci. Microbiol., 1: 20–27.
Siddika F, M Shahjahan and M Rahman, 2013. Abundance of plankton population densities in relation to bottom soil textural types in aquaculture ponds. Int. J. Agric. Res. Innov. Technol., 2: 56–61.
Siddique AB, M Moniruzzaman, S Ali, MN Dewan, MR Islam, MS Islam, MB Amin, D Mondal, AK Parvez and ZH Mahmud, 2021. Characterization of pathogenic *Vibrio parahaemolyticus* isolated from fish aquaculture of the Southwest coastal area of Bangladesh. Front. Microbiol., 12: 1–15.
Sipaúba-Tavares L, A Donadon and R Milan, 2011. Water quality and plankton populations in an earthen polyculture pond. Brazilian J. Biol., 71: 845–855.
Sumantri I, L Buchori, FAW Mukti, F Ramadhani and DD Anggoro, 2020. Study of the rate of adsorption of toxic gases in shrimp ponds using Sukabumi natural zeolite. AIP Conf. Proc., 2197: 120005.
Sunny AR, SH Prodhan, M Ashrafuzzaman, MH Mithun, M Hussain, MT Alam, A Rashid and MM Hossain, 2021. Fisheries in the context of attaining Sustainable Development Goals (SDGs) in Bangladesh: COVID-19 impacts and future prospects. Sustainability, 13: 1–35.
Thornber K, D Huso, MM Rahman, H Biswas, MH Rahman, E Brum and CR Tyler, 2019. Raising awareness of antimicrobial resistance in rural aquaculture practice in Bangladesh through digital communications: a pilot study. Glob. Health Action, 12: 1734735.
Toufique KA and B Belton, 2014. Is aquaculture pro-poor? empirical evidence of impacts on fish consumption in Bangladesh. World Dev., 64: 609–620.
Trottet A, C George, G Drillet and FM Lauro, 2021. Aquaculture in coastal urbanized areas: A comparative review of the challenges posed by Harmful Algal Blooms. Crit. Rev. Environ. Sci. Technol., 1: 1–42.
Ullah MA, MA Naeem, A Hossain, A Al-Asif and MR Hasan, 2020a. Categorization and distribution of aqua-chemicals used in coastal farming of south-eastern part of Bangladesh. J. Aquac. Res. Dev., 11: 1–7.
Ullah MA, M Rahman, MR Hasan, MM Hasan and MS Hossain, 2020b. Present status and economic benefit of integrated fish farming system in Noakhali region, Bangladesh. Asian J. Med. Biol. Res., 6: 525–529.
Vaumik S, SK Sarker, MS Uddin, MT Alam, A Satter and A Al-Asif, 2017. Constraints and prospects of fish farming in Lalmonirhat district. Int. J. Business, Soc. Sci. Res., 5: 201–210.
Verschuere L, G Rombaut, P Sorgeloos and W Verstraete, 2000. Probiotic bacteria as biological control agents in aquaculture. Microbiol. Mol. Biol. Rev., 64: 655–671.
Watts JEM, HJ Schreier, L Lanska and MS Hale, 2017. The rising tide of antimicrobial resistance in aquaculture: Sources, sinks and solutions. Mar. Drugs, 15: 1–16.
Yu X, E Dimitriou, S Konstantinos, V Markogianni and D Politi, 2015. Effects of yucca shidigera extract on the reduction of ammonia concentration in lake Koumoundourou. J. Ecol. Eng., 16: 1–7.
Zorriehzahra MJ, ST Delshad, M Adel, R Tiwari, K Karthik, K Dhama and CC Lazado, 2016. Probiotics as beneficial microbes in aquaculture: an update on their multiple modes of action: a review. Vet. Q., 36: 228–241.