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An assessment of chemical and biological product use in aquaculture in Bangladesh

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ABSTRACT

The aim of this study is to describe current chemical use practices in the aquaculture sector of Bangladesh and to identify the factors that influence them. A survey on the use of chemical and biological products was conducted between November 2011 and June 2012 using structured questionnaires administered to operators of nine farm groups, including homestead ponds, carps, tilapias, koi fish, shrimps, shrimps and prawns, prawns, rice and fish, and pangas. Farm type and farm owner characteristics were used as independent variables to explain observed chemical use. Forty-six chemical and biological products (7 water and sediment treatment compounds, 13 disinfectants, 7 antibiotics, 7 pesticides, 8 fertilizers and 4 feed additives and probiotics) were reported to be applied in aquaculture. The use of disinfectants and antibiotics was found to be highest in intensive koi and pangas farms as compared to other farm groups, whereas the use of fertilizers was lowest in these farm groups. A higher percentage of prawn and shrimp/prawn farmers applied pesticides than other farm groups. A multivariate analysis showed that patterns of use of chemical and biological products were significantly different across aquaculture farm groups, with the largest number of chemical compounds used by the intensive koi farm group. The study shows that, despite rapid expansion of commercial aquaculture in Bangladesh, use of chemical and biological products is still relatively low compared to other aquaculture producing countries in Asia. However, despite this finding, the study identified a large number of compounds that are currently in use, and that require further regulation and evaluation regarding their potential environmental and human health impacts, as already done in most developed countries.

Statement of relevance: Chemical use practices in Bangladesh

1. Introduction

Bangladesh is the fifth largest aquaculture producing country in the world (FAO, 2014) with a total production of more than 1.85 M tons in 2012–2013 (DoF, 2014). The vast majority of the aquaculture in Bangladesh takes place in freshwater and brackish water production systems, in many cases integrated with other agricultural crops such as rice or vegetables (Ahmed and Garnett, 2010; Ali and Haque, 2011; Belton et al., 2011; Wahab et al., 2012; Jahan et al., 2016). Over the last two decades, the Bangladeshi aquaculture sector has expanded, diversified and advanced technologically with an increasing trend towards the intensification of cultivation methods in some regions (Ali, 2009; Belton and Azad, 2012; Ali et al., 2013). With the expansion and intensification of the aquaculture sector, there has been an increasing demand for the use of chemicals and biological products (Faruk et al., 2008). Natural and synthetic substances such as antibiotics, disinfectants, water and soil treatment compounds, pesticides, fertilizers, probiotics, and other feed additives have become crucial inputs to treat and prevent bacterial and parasitic diseases, to improve water quality, to increase pond natural productivity and/or as growth promoters (Subasinghe et al., 1996; Bondad-Reantaso et al., 2005; Rico et al., 2013).

Use of these chemicals can contribute to the increased productivity and growth of the aquaculture sector, but has also attracted criticism due to possible negative consequences for human and environmental health (Subasinghe et al., 2000; Graslund and Bengtsson, 2001; Holmström et al., 2003; Heuer et al., 2009; Uddin and Kader, 2006; Sapkota et al., 2008; Rico et al., 2013). Residues of potentially toxic substances such as pesticides or antimicrobials can accumulate in the treated animals, resulting in a potential hazard for consumers and for the marketing and export of aquaculture produce (Heuer et al., 2009; Sapkota et al., 2008). The extensive use of antibiotics in aquaculture can contribute to the development of antimicrobial-resistant pathogenic bacteria both inside and outside the aquaculture facilities (Le et al., 2005; Sørum, 1999; Inglis, 2000). Moreover, some antibiotics are moderately to highly toxic to non-target bacteria and primary

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producers (Wollenberger et al., 2000; Flaherty and Dodson, 2005; Grinten et al., 2010; Rico et al., 2014; Yasser and Adli, 2015; Andrieu et al., 2015), thus possibly contributing to the degradation of aquatic ecosystems receiving aquaculture effluents (Rico et al., 2012).

Around 100 pharmaceuticals companies produce over 400 different aquaculture chemical products commercialized in Bangladesh (Alam and Rashid, 2014). However, knowledge on the number of active ingredients and the chemical use practices implemented in different aquaculture production systems and regions of Bangladesh is rather limited. A small number of studies have reported on the application of chemicals in aquaculture in individual aquaculture systems in Bangladesh, and usually draw on small samples of farms producing specific species (MacRae et al., 2002, Faruk et al., 2005; Alday-Sanz et al., 2012; Hossain et al., 2013a; Hossain et al., 2013b; Rico et al., 2013). These studies therefore have limited capacity to fully describe the national situation and to provide extensive comparative assessments. The collection of detailed information on the use of chemical and other inputs in aquaculture is crucial in evaluating their potential risks for human health and for the environment, as well in evaluating prudent use of such compounds, and their effectiveness for preventing and treating disease outbreaks. In this study we report findings from the largest chemical use survey performed in Bangladesh to date, which includes almost 1900 farms belonging to nine farm groups, including homestead ponds, carps, tilapias, koi fish, shrimps, shrimps and prawns, prawns, rice and fish, and pangas (see Table 1 for a definition). The study offers a comparative assessment of current chemical use practices in the nine farm groups and describes factors that influence them, with the objective of identifying production technologies and practices that require further governmental support or risk evaluation.

2. Material and methods

2.1. Study area and farm interviews

This study was performed as a part of the United States Agency for International Development (USAID) funded *Cereal Systems Initiative for South Asia* (CSISA) project. CSISA worked in six geographical "hubs" covering most of the major aquaculture producing areas in the country (Fig. 1). Four additional districts located outside the CSISA hubs, which were identified as having high concentrations of aquaculture operations, were also included in the survey. The survey deliberately targeted areas in which there had been no project activity in order to obtain a benchmark of the practices employed and only 1% of the surveyed farms reported having received project training. A purposive stratified sampling strategy was adopted, as aquaculture development in Bangladesh occurs in a highly geographically clustered manner, making it very difficult to sample representatively over a broad area. A number of steps were followed to select sample farms for the study (see Jahan et al., 2016 for details). The major aquaculture production systems in each hub or district were identified, and the most important (in terms of geographical distribution and contribution to national fish production) nine farm groups, defined in terms of the major species produced and the production technology used, were selected for further study (see Table 1 for details of characteristics of the nine farm groups).

The chemical use survey was conducted between November 2011 and June 2012. Twenty-four enumerators, who had completed BSc degrees in aquaculture, participated in the survey. A total number of 1890 farms were surveyed, with interviews being conducted with farm owners (84%), farm managers (9%), farm assistants (7%) or farm technicians. Information was collected using a structured questionnaire covering detailed information on chemical and biological products used in aquatic health management (e.g. active ingredients, frequency of application), disease occurrence, basic farm infrastructure and production characteristics (e.g. number of ponds, production cycles per year), and education and training level of the respondents. The draft questionnaire was pre-tested and revised repeatedly prior to finalization. In addition, focus group discussion meetings were organized at village level to identify the main disease symptoms faced by each of the different farm groups studied. Respondents were asked to report the disease symptoms that they had observed during the last production year. The findings of this session were summarized by a specialist, and respondents ranked the diseases based on the frequency of outbreak. Key informant interviews were conducted with aquaculture medicine retailers and marketing representatives for veterinary chemical companies at the district and sub-district level, in order to generate an inventory of product names and the principal active ingredients contained in such products.

2.2. Compound classification

The reported chemical and biological products were classified into seven categories: 1) water and soil treatment compounds, 2) fertilizers, 3) disinfectants, 4) antibiotics, 5) pesticides, 6) feed additives, and

Table 1
Characteristics of the nine farm groups included in the present study.

Farm group abbreviation	Major species	Main production system [a]	Number of surveyed farms
Homestead pond	Indian major carp[b], Indian minor carp[c], Exotic carp[d]	Extensive to semi-intensive polyculture (homestead ponds)	381
Carp	Indian major carp[b], Indian minor carp[c], Exotic carp[d]	Semi-intensive polyculture (freshwater ponds)	212
Tilapia	Tilapia (*Oreochromis niloticus*)	Semi-intensive polyculture (freshwater ponds)	95
Koi	Koi (*Anabas testudineus*)	Intensive polyculture (freshwater ponds)	97
Shrimp	Shrimp (*Penaeus monodon*)	Improved extensive (brackish water gher[e])	310
Shrimp and prawn	Shrimp (*Penaeus monodon*) and prawn (*Macrobrachium rosenbergii*)	Improved extensive concurrent with rice (brackish water/freshwater gher)	134
Prawn	Prawn (*Macrobrachium rosenbergii*)	Improved extensive concurrent with rice (freshwater gher)	212
Rice-fish	Indian major carp[b], Indian minor carp[c], Exotic carp[d]	Improved extensive polyculture (rice-field)	134
Pangas	Pangas (*Pangasianodon hypophthalmus*)	Intensive polyculture (freshwater ponds)	321

Homestead pond, homestead pond aquaculture; carp, commercial carp culture in pond; tilapia, commercial tilapia culture in pond; koi, commercial koi culture in pond; Shrimp, commercial shrimp culture in gher; shrimp and prawn, commercial shrimp and prawn culture in gher; prawn, commercial prawn culture in gher; rice-fish, rice and fish culture in rice field; pangas, commercial pangas culture in pond.

[a] Please see Jahan et al. (2016) for a detailed definition of the production systems.

[b] Indian major carp (Rohu, *Labeo rohita*; catla, *Catla catla*; Mrigel, *Cirrhina mrigala*).

[c] Indian minor carp (Calibaush, *Labeo calbasu*; Gonia, *Labeo gonius*; Bata, *Labeo bata*).

[d] Exotic carp (Silver carp, *Hypophthalmichthys moltrix*; Bighead carp, *Aristichthys nobilis*; Grass carp, *Ctenopharyngodon idella*; Common carp, *Cyprinus carpio*; Black carp, *Mylopharyngodon piceus*; Silver barb, *Barbonymus gonionotus*).

[e] The term *gher* refers a paddy field which has been modified for shrimp or prawn production. Typically, paddy is cultivated in the middle of the field, which is surrounded by canals with high wide dikes into which the shrimp are stocked.