

The Use of Chemicals in Carp and Shrimp Aquaculture in Bangladesh, Cambodia, Lao PDR, Nepal, Pakistan, Sri Lanka and Viet Nam

Michael Phillips

Network of Aquaculture Centres in Asia-Pacific
P.O. Box 1040, Kasetsart Post Office
Bangkok 10903, THAILAND

ABSTRACT

This paper provides an overview on the use of chemicals in seven countries in Asia (Bangladesh, Cambodia, Nepal, Laos PDR, Pakistan, Sri Lanka and Viet Nam), with an emphasis on coastal shrimp aquaculture and inland carp farming systems. The data come primarily from a recently completed survey of aquaculture farms in Asian countries conducted under the ADB/NACA Regional Study and Workshop on Aquaculture Sustainability and Environment. The issues discussed include the types and uses of chemicals in shrimp and carp culture, farm management practices and use of chemicals, hazards and adverse impacts associated with chemical use, alternative approaches to chemical use, and research recommendations. In inland carp farming, apart from lime and fertilizers, which are unlikely to give rise to any significant negative environmental impact, the overall use of chemicals is extremely low. Piscicides are used in some countries to control predators prior to stocking of ponds, but the use of antimicrobials and disease-control chemicals is limited to a small percentage (<5%) of producers. Most small-scale producers, who dominate aquaculture production in these countries, simply do not have the resources or need for such chemicals. The situation is similar in shrimp culture, with lime and fertilizers, followed by piscicides, being the most common chemicals used. The use of antimicrobials increases with intensification in shrimp culture, and these chemicals are mostly used in more intensive shrimp farming. In both shrimp and carp culture, promotion of “primary” health management practices probably offers greatest scope for prevention of aquatic animal disease outbreaks and the need for chemical use.

INTRODUCTION

This paper summarizes information on the use of chemicals in several countries in Asia, with an emphasis on coastal shrimp aquaculture and inland carp farming systems. The data come from a recently completed survey of aquaculture farms in Asian countries conducted under the ADB/NACA Regional Study and Workshop on Aquaculture Sustainability and Environment (ADB/NACA 1996, 1998).

The paper briefly deals with the following issues:

- Types and uses of chemicals in shrimp and carp culture
- Farm management practices and use of chemicals
- Hazards and adverse impacts associated with chemical use
- Alternative approaches to chemical use
- Research recommendations
- Conclusions and recommendations

The information presented in this paper comes from several sources:

- Primary data collected by questionnaire as part of the farm-level surveys conducted for the ADB/NACA Regional Study and Workshop on Aquaculture Sustainability and Environment (ADB/NACA 1996). The survey covered coastal shrimp farming systems in 13 countries and inland carp farming systems in 14 countries. The data presented come from farm crops in 1994 and 1995. The survey included only ponds and not hatcheries. Carp farming systems were chosen because of their importance as inland food producing systems in many Asian countries, and shrimp farming because of its importance as an export sector in the region.
- Secondary data collected as part of the ADB/NACA study and previous FAO/NACA study on the Environmental Assessment and Management of Aquaculture Development (FAO/NACA 1995).
- Selected secondary national and regional literature.

The following classification was used for the chemical types recorded during the farm-level survey:

- Therapeutants
- Disinfectants
- Pesticides/piscicides
- Soil and water treatments
- Feed additives

The survey generally covers chemicals used in water treatment ponds (shrimp only), for pond preparation, during grow-out operations and for control of carp or shrimp diseases.

RESULTS

Bangladesh

Inland Carp Culture

The survey included 96 extensive carp farms and 522 semi-intensive carp farms. Extensive farms were classified as low-input farms with limited pond inputs apart from stocking of fish seed and low outputs in terms of fish productivity (yields generally <0.5 MT/ha/yr).

Pond preparation: The most commonly used chemical for pond preparation in carp culture was lime (used on 7% of extensive farms and 80% of semi-intensive farms). Rotenone was used on 1% of extensive farms and 11% of semi-intensive farms as a piscicide to remove “weed fish” prior to stocking of culture fish. Various forms of organic and inorganic fertilizers (1-70%) were used for pond preparation. Use of Phostoxin (a compound used as a piscicide) was also reported by only 6% of semi-intensive carp farmers.

During grow-out operations: The only chemicals used during grow-out operations were lime, which was used on 9% of semi-intensive farms, and organic/inorganic fertilizer, used on 5% of the extensive farms and all (100%) of the semi-intensive farms.

Fish disease control: The main disease problem in freshwater carp culture in Bangladesh was epizootic ulcerative syndrome (EUS). Fish diseases affected 31% of extensive farms and 24% of semi-intensive carp farms. Most farmers made no attempt to control disease outbreaks. Where farmers did use chemicals, the most common treatments were salt, lime (between 28 and 33% of farms), potassium permanganate (15% of semi-intensive farms) and occasionally dipterex. Antimicrobials (e.g., oxytetracycline and oxolinic acid) were used on less than 5% of farms affected by disease.

Coastal Shrimp Culture

The survey covered 23 semi-intensive shrimp farms and 251 extensive farms. Extensive shrimp farming contributes the bulk of shrimp produced in Bangladesh.

Water treatment ponds: Lime was used to treat water treatment ponds on all semi-intensive farms, and chlorine was used on 25% of these farms. Extensive farms did not use water treatment ponds.

Pond preparation: The most commonly used chemical for pond preparation in shrimp culture was again lime (used on 56% of extensive farms and 96% of semi-intensive farms). Teaseed cake was also in common use to remove fish prior to stocking shrimp (11% of extensive farms and 74% of semi-intensive farms). No other chemicals were reported to be used during pond preparation.

During grow-out operations: The only chemicals reported during grow-out operations were lime (27% of semi-intensive farms and 87% of extensive farms) and organic/inorganic fertilizer, used on 9% of extensive farms and 52% of semi-intensive shrimp farms.

Shrimp disease control: Disease is an important problem in semi-intensive and extensive shrimp culture in Bangladesh, affecting 13% of extensive farms and 74% of the semi-intensive farms. Of the farmers affected by disease, most extensive farmers did not use chemicals. Six percent of farms reported using chemical treatments, with oxytetracycline (mixed in feed) being the most commonly used antimicrobial. Chemical use for disease treatment was higher on semi-intensive farms, with 38% of farms reporting some use of chemical treatments. Again, oxytetracycline was the most commonly used chemical, but with chloramphenicol, oxolinic acid, BKC and formalin also occasionally reported.

Cambodia

Inland Carp Culture

Inland carp culture in Cambodia is still in the early stages of development, with most of the country's fish production coming from capture fisheries. The survey covered 148 farms, which were all classified as semi-intensive, with extrapolated fish yields of around 952 kg/ha/yr.

Pond preparation: Farmers used only lime (50% of farms), rotenone for removing predatory fish before fish stocking (64% of farms) and inorganic or organic fertilizer (>88% of farms).

During culture operations: The only chemicals used during grow out were lime (only 5% of farms) and organic/inorganic fertilizer (all farms).

Fish disease control: Only 11% of farms reported any disease problems and oxytetracycline had been used for disease control on around half of these affected farms.

Coastal Shrimp Culture

The survey in Cambodia covered both extensive and intensive shrimp farms, the latter having developed in Koh Kong Province close to the border with Thailand. The survey covered 32 intensive farms and 39 extensive shrimp farms.

Water treatment ponds: Water treatment ponds were used on 56% of the intensive farms. Lime (used by 61% of farms) and BKC (used by 11%) were the most commonly used chemicals.

Pond preparation: No chemicals were used in extensive shrimp farms, but lime (97%) and teaseed cake (66%) were used to prepare ponds prior to stocking shrimp in intensive farms.

During culture operations: No chemicals were used by extensive shrimp farmers and only lime (97% of farms) and organic/inorganic fertilizer (84% of farms) were used during grow-out operations on intensive shrimp ponds.

Shrimp disease treatment: Shrimp disease was not reported at all by extensive shrimp farmers but was common in intensive culture, affecting 81% of the farms surveyed. Oxytetracycline (38%), unknown local herbs/medicine (6%), BKC (30%) and formalin (6%) were reportedly used on the farms affected by disease.

Lao PDR

The Lao PDR was not covered during the survey, but information available from secondary sources (FAO/NACA 1995) indicates that chemical use in freshwater aquaculture is extremely low. The major chemicals reported to be used are lime and inorganic or organic fertilizers.

Nepal

Inland Carp Culture

The survey covered 345 extensive farms and 150 semi-intensive farms culturing carp. The majority of carp farms in Nepal are low-input/low-output farms and consequently, the chemical use in most farms is very low.

Pond preparation: Pond preparation involved only lime (15% of extensive and 67% of semi-intensive farms), organic fertilizer (1% of extensive and 32% of semi-intensive farms) and inorganic fertilizer (3% of extensive and 12% of semi-intensive farms). Use of piscicides was surprisingly low.

During culture operations: Chemical use during grow-out was similarly limited only to organic fertilizer (11% of extensive and 58% of semi-intensive farms), inorganic fertilizer (5% of extensive and 47% of semi-intensive) and lime (11% of semi-intensive farms).

Fish disease control: Fish disease (mainly EUS) affected 18% of extensive carp ponds and 39% of semi-intensive carp farms. The only treatments used were potassium permanganate (16% of semi-intensive farms) and dipterex (on an uncertain number of extensive and semi-intensive farms).

Pakistan

Inland Carp Culture

Inland aquaculture is a relatively new activity in Pakistan, with only around 5,000 farms throughout the country at the time of the survey. Fifty extensive farms and 729 semi-intensive farms were covered during the survey.

Pond preparation: Lime (24% of extensive and 64% of the semi-intensive farms), organic fertilizer (21% of extensive and more than 72% of semi-intensive farms) and inorganic fertilizer (no extensive but 46% of semi-intensive farms) were the main chemicals used in pond preparation.

During culture operations: Similarly, only organic fertilizer (6% of extensive and 71% of semi-

intensive farms), inorganic fertilizer (3% of extensive and 55% of semi-intensive farms) and lime (9% of semi-intensive farms) were used during fish culture operations.

Fish disease control: Fish disease was only a minor problem at the time of the survey, with only 9% of extensive farms and 2% of semi-intensive farms reporting any losses. For those farms reporting disease outbreaks, unknown antimicrobials, malachite green, potassium permanganate and lime had been used by farmers to control diseases.

Sri Lanka

Coastal Shrimp Culture

The survey in Sri Lanka only examined coastal shrimp culture, covering 90 extensive farms, 130 semi-intensive farms and 36 intensive farms.

Water treatment ponds: Only a small number of farms used water treatment ponds (2% of semi-intensive and 6% of intensive farms). Lime was the only water treatment chemical used, on 50% of intensive farms.

Pond preparation: Chemical use during shrimp pond preparation involved only lime (100% of extensive, 98% of semi-intensive and 97% of intensive farms), teaseed cake (11% of extensive, 19% of semi-intensive and 25% of intensive farms) and fertilizer (21% of extensive, 8% of semi-intensive and 11% of intensive farms).

During culture operations: The only chemicals used were lime (68% of extensive, 71% of semi-intensive and 75% of intensive farms), organic fertilizer (5% of extensive, 7% of semi-intensive and 8% of intensive farms) and inorganic fertilizer (21% of extensive, 30% of semi-intensive and 25% of intensive farms).

Shrimp disease control: Shrimp disease was reported in all farm types (16-21-17%). Eleven percent of the affected semi-intensive farms used malachite green to treat disease, while 19% of the affected semi-intensive farms and 50% of the affected intensive farms used lime. Intensive and semi-intensive farms did not report any use of antimicrobials for shrimp disease control. Twenty-five percent of the affected extensive farms reported the use of oxtetracycline in feed.

Viet Nam

Inland Carp Culture

Viet Nam has a large number of farms producing carp, which is an important food item in rural areas. The survey covered 124 semi-intensive and 54 extensive farms culturing carp in ponds in the northern, central and southern parts of the country.

Pond preparation: Farmers reported only using lime (24% of extensive and 64% of semi-intensive farms), organic fertilizer (22% of extensive and 42% of semi-intensive farms) and inorganic fertilizer (17% of extensive and 19% of semi-intensive farms) for pond preparation.

During culture operations: The use of chemicals in carp grow-out was similarly limited to lime (4% of extensive and 1% of semi-intensive farms), organic fertilizer (52% of extensive and 61% of semi-intensive farms) and inorganic fertilizer (17% of extensive and 21% of semi-intensive farms).

Fish disease treatment: Disease was reported as a problem on 26% of extensive farms and 18% of

semi-intensive farms. The types of disease reported varied (no EUS was reported). The methods of treatment were similarly varied. They included unspecified antibiotics (only on 5% of affected semi-intensive farms), various local herbs and medicines (29% of affected extensive and 23% of affected semi-intensive farms), and copper sulphate (only used on 14% of extensive farms). The use of local herbs is particularly interesting and would warrant further investigation.

Coastal Shrimp Culture

Although coastal shrimp culture has developed rapidly in Viet Nam in recent years, most shrimp farming is still carried out in very extensive farming systems. The survey covered 400 extensive farms and 81 semi-intensive farms throughout the country.

Water treatment ponds: A small number of semi-intensive farms (only 8%) had water treatment ponds, of which 27% used lime for water treatment. No other chemicals were used.

Pond preparation: Lime was commonly used for pond preparation (37% of extensive and 80% of semi-intensive farms). Teaseed cake (13% of extensive and 13% of semi-intensive farms) and rotenone (46% of extensive and 63% of semi-intensive farms) were used as piscicides for removing shrimp predators before stocking.

Pond treatment after stocking: Lime was used on 3% of extensive farms and 17% of semi-intensive farms. Inorganic fertilizer (3% of extensive and 12% of semi-intensive farms) and organic fertilizer (5% of extensive and 15% of semi-intensive farms) were also occasionally used to increase pond fertility after stocking of shrimp.

Shrimp disease control: Shrimp disease is an important constraint in Viet Nam, even though much of the shrimp farming is extensive. Disease was reported on 57% of the extensive and 66% of the semi-intensive farms. The overall use of chemicals was low, but of those attempting chemical treatments, farmers reported use of oxytetracycline (1-7% of affected farms), "other" antibiotics (5% of extensive and 16% of semi-intensive farms) and some herbal medicine/other treatments (8% of extensive and 2% of semi-intensive farms).

FARM MANAGEMENT AND THE USE OF CHEMICALS

General Findings

The farm survey in these six countries showed that the most common chemicals in use on inland carp farms are lime and fertilizers. These chemicals are used for soil and water treatment and for generating fertility in ponds, and pose limited environmental and public health risks.

Piscicides such as rotenone and teaseed cake are the second most common class of compounds used after water and soil treatments. Some of the chemicals potentially pose some local risks to the environment and health if not used carefully.

The use of chemicals for disease control in these countries is very low, with less than 5% of farmers in all countries using any form of antimicrobial compound.

In coastal shrimp farming, the survey also showed that lime and fertilizers were the most common chemicals used in the five countries where shrimp are cultured, mainly for water and soil treatment. Piscicides were the second most common class of chemicals, followed by disease-control chemicals. Use of antimicrobials generally increased with intensity of farming, and the frequency of use of disease control chemicals was higher than in carp culture. However, results suggest that the use of antimicrobial compounds is much less widespread than is commonly perceived.

Economics of Chemical Use

The survey data allow some analyses and comparisons between countries and between farming systems based on the expenditure by farmers on different chemicals. Table 1 shows the expenditure in \$/ha/yr spent on chemicals excluding fertilizer costs for carp culture in the different countries. The amounts spent are generally very low and (except for Nepal) increase from extensive to semi-intensive producers. The amounts spent represent less than 1% of carp production costs, which averaged from \$1,000-2,000/ha/yr for extensive farms and \$6,000-13,000/ha/yr for semi-intensive farms (ADB/NACA 1998).

Table 1. Estimated expenditure (\$US/ha/yr) on chemicals (excluding fertilizers) in several carp-producing countries.

	Bangladesh	Cambodia	Nepal	Pakistan	Viet Nam
Extensive	0.7		12.6	0.7	0.1
Semi-intensive	7.3	0.95	10.9	7.8	2.9

Table 2 shows the estimated expenditure on fertilizers. The amount spent in semi-intensive farming is significantly higher than expenditure on other chemicals.

Table 2. Estimated expenditure (\$US/ha/yr) on organic and inorganic fertilizers in several carp-producing countries.

	Bangladesh	Cambodia	India	Nepal	Pakistan	Viet Nam
Extensive	0		19.2	169	0.3	27.4
Semi-intensive	69.7	158.7	300	166.9	29	399.4

Tables 3-5 show similar calculations for shrimp culture in four countries. Expenditure on chemicals is again very low in extensive farming but increases in semi-intensive and intensive farming. Expenditure on chemicals is higher in semi-intensive shrimp farming than in semi-intensive carp culture and shows an increasing trend for the more intensive farming systems. Fertilizer use is lower than in carp culture. The expenditure on chemicals ranged from less than 1% to 6.0% of operating costs in extensive (\$5-4400/ha/yr), semi-intensive (\$2,200-18,400/ha/yr) and intensive culture (\$13,100-28,400/ha/yr) and up to \$0.29/kg of shrimp.

Table 3. Estimated expenditure (\$US/ha/yr) on chemicals (excluding fertilizers) in shrimp aquaculture (figures in brackets give the percent of operating costs).

	Bangladesh	Cambodia	Sri Lanka	Viet Nam
Extensive	4.5 (0.7%)	0 (0%)	15.3 (0.3%)	2.3 (1.7%)
Semi-intensive	477.7 (3.3%)		235.7 (1.3%)	44.6 (2.0%)
Intensive		791.9 (6.0%)	276.6 (1.0%)	

Table 4. Estimated expenditure on chemicals in \$US per kg of shrimp produced.

	Bangladesh	Cambodia	Sri Lanka	Viet Nam
Extensive	0.02	0	0.01	0.03
Semi-intensive	0.29		0.05	0.07
Intensive		0.19	0.04	

The expenditure on fertilizer was very low and less than in carp culture.

Table 5. Estimated expenditure (\$US/ha/yr) on organic and inorganic fertilizers in shrimp culture.

	Bangladesh	Cambodia	Sri Lanka	Viet Nam
Extensive	18.2	0	1.8	0.5
Semi-intensive	46.3	0	26.4	15.4
Intensive		61	3.9	

Hazards and Adverse Impacts

Cultured organisms

The bulk of chemicals used are fertilizers and lime, which are expected to have no adverse environmental impacts. These chemicals are widely used in agriculture as soil conditioners. Fertilizers are an important source of fertility in inland carp farming. The use of agricultural by-products in integrated farming can contribute to efficient use of nutrients and organic matter and environmental improvement (Edwards 1993).

Of the chemicals used for fish and shrimp disease control, a notable feature of the results is that farmers have a very mixed success in controlling disease problems. This suggests that more emphasis is needed on development of effective health management strategies at the farm level.

Antibiotic resistance

There is very little information on this subject available from the survey data. However, there are reports from other sources of resistance to antibiotics occurring in shrimp hatcheries in Viet Nam, and recently some research work by the Aquatic Animal Health Research Institute (AAHRI) has found antibiotic resistance in Bangladeshi carp farms (Chowdhury and Inglis 1994). The latter is interesting given the apparent low use of antibiotics in carp culture in this country. Given the generally low level of antimicrobial use in inland carp farming, the risk of antibiotic resistance arising from such farming systems is considered low. There is clearly a need to better understand the sources and effects of antibiotic resistance where it does occur.

Effects of chemicals on farm workers and consumers

There is a lack of information on the effects of chemicals on farm workers and consumers. In general, the low use of chemicals in these countries suggests that adverse effects are unlikely. In

some isolated cases, the use of certain chemicals, such as piscicides, chloramphenicol and malachite green, may pose a risk to farmer and worker health. Care in the handling and use of such chemicals would be necessary to reduce health risks.

Marketing problems

No marketing problems associated with chemical use in aquaculture products have been reported in these countries. Indeed, the extensive systems commonly used for carp and shrimp in these countries may even offer opportunities for marketing of aquaculture products which have been raised with little, if any, use of chemicals.

Environmental aspects

The major chemicals used are fertilizers and lime, which are not expected to cause adverse environmental impacts, and no environmental problems were raised in the surveyed countries. Where certain higher toxicity compounds are being used as piscicides, then further assessment is necessary to determine the environmental impacts of these chemicals. Baird (1992) has identified the use of piscicides as a possible environmental hazard in freshwater aquaculture and recommended further research to assess impacts and develop alternatives. Concern has also been raised in Bangladesh of the impacts on indigenous fish species when piscicides are used in oxbow lakes and other large water bodies as part of large-scale fish restocking programs.

Measures employed to improve productivity

Fertilizers are the most important chemicals used in freshwater carp culture and are an important source of fish productivity within these systems. As is well known, there are a range of inorganic and organic fertilizers used in inland carp culture. One important issue is the efficiency with which fertilizers are used. Efficiency studies carried out on carp culture data collected during the survey (ADB/NACA 1998) suggest significant differences in the efficiency of fertilizer use in different countries and farming systems, an aspect which requires further investigation. In shrimp culture, fertilizers are applied in lesser amounts than in carp culture and are mainly used for the stabilization of plankton blooms in intensive shrimp aquaculture.

Examples of alternative approaches

Some work has been carried out on alternatives to piscicide use. Work in Thailand has shown that stocking of larger-sized fingerlings, previously grown in hapas, results in less loss due to predation than does stocking of smaller-sized fish (Little *et al.* 1991), thus reducing the need for predator control using piscicides. There is also interesting work on “integrated pest management” in some parts of the world, such as with the control of sealice (Deady *et al.* 1995). Prevention of shrimp disease through systems management is also now being widely promoted (AAHRI 1994). Such approaches need to be further explored for carp and shrimp aquaculture systems.

Research Recommendations

The following are the major research issues, mainly summarized from the recent ADB/NACA survey and earlier FAO/NACA (1995) study.

- Research is needed on the development of preventative “systems” approaches to health management in aquaculture. Systems approaches would help to reduce the likelihood of disease outbreaks through preventative approaches in aquatic animal health care. Such approaches are particularly relevant to the countries surveyed for this paper, as aquaculture is still relatively under-developed and extensive in these countries.

- Research is needed to provide a better understanding of the risk of chemicals in use, with an emphasis on piscicides used for pond preparation and antimicrobials.
- Research on existing chemical usage would be useful to properly assess the extent of the problems. It is also necessary to put antimicrobial use in aquaculture within the overall picture of antimicrobial use in other sectors, before the wider significance of their use in aquaculture can be determined.
- The survey revealed the use of several “traditional” chemicals and indigenous products for disease control, particularly in Viet Nam. Further research should explore the use and effectiveness of these different preparations.
- The possibility of using IPM (integrated pest management) in aquaculture should be further investigated.

In all research work, more emphasis should be given to linking research findings to farmers and other end users.

Regulatory Measures

An obvious regulatory measure is the need for proper product identification and labeling. The legal and other issues relating to chemical use should be further examined in these countries. The FAO Code of Conduct for Responsible Fisheries identifies the importance of appropriate legislation which includes aquaculture chemicals (FAO 1995). Work on development of aquaculture legislation is ongoing in Viet Nam, supported by Norway and the FAO, and would provide opportunities for exploring the need for and development of such legislation.

Data/Information Availability

There is a need to build awareness on safe and effective use of chemicals in aquaculture. This information could be in the form of technical guidelines, extension materials for farmers and through promoting the sharing of information within and between countries. The countries surveyed during this study could also benefit from learning of experiences in other countries within the Asia-Pacific Region.

International Trade Issues

It is likely that issues related to the use of chemicals in aquaculture will be given increasing attention in international trade (Howarth 1997), particularly for export products such as shrimp. It is important that governments and producers are aware of the likely implications of the use of certain chemicals for trade and take precautionary measures to minimize their use and impact on product quality.

CONCLUSIONS AND RECOMMENDATIONS

This survey of carp and shrimp farming systems has provided an overview of chemical use in six countries. In inland carp farming, apart from lime and fertilizers, which are unlikely to give rise to any significant negative environmental impact, the overall use of chemicals is extremely low. Piscicides are used in some countries to control predators prior to stocking of ponds, but the use of antimicrobials and disease-control chemicals is limited to all but a small percentage (<5%) of producers. Most small-scale producers, who dominate aquaculture production in these countries, simply do not have the resources or need for such chemicals.

The situation is similar with shrimp culture in the surveyed countries, with lime and fertilizers, followed by piscicides, being the most common chemicals used. The use of antimicrobials increases

with intensification in shrimp culture, and these chemicals are mostly used in more intensive shrimp farming. Intensive shrimp farmers in Sri Lanka did not use any antimicrobial compounds. In both shrimp and carp culture, promotion of “primary” health management practices probably offers the greatest scope for prevention of aquatic animal disease outbreaks and the need for chemical use.

The following recommendations are directed to different groups as required in the guidelines used for preparation of this paper, and are based on the findings from this review.

To Farmers:

It is the impression from the survey results and other discussions with farmers that farmers are mainly searching for solutions to the day-to-day problems they face, particularly when disease outbreaks are encountered. Farmers may be easily “tempted” by various “cures” presented to them by different marketing groups, as emphasized by Fegan (1996). It is the responsibility of the government and scientific community to ensure that farmers are properly supported with information and technical assistance which provides appropriate advice on farm management and on environmentally safe ways of using approved chemicals. The importance of basic preventative health care for cultured fish and shrimp cannot be overemphasized as one key way to minimize the need for using disease control chemicals (e.g., see the excellent manual by AAHRI 1994).

To Chemical Producers and Suppliers:

Chemical producers and marketers should be responsible for proper labeling of products, substantiation of claims and precautionary measures for reducing risks from improper use of the chemicals.

To Government Agencies and Institutions:

Government agencies have a responsibility for fair regulations on chemical use and provision of appropriate information to farmers. Researchers also have a responsibility for provision of appropriate information on chemical use and impacts and for development of farming systems and practices which promote environmentally sound aquaculture production.

To Regional and International Organizations:

Regional and international organizations can support national agencies through information exchange, capacity building and promotion of research cooperation.

To Scientists:

Scientists have an important role to play in promoting research along the lines outlined above; however, a closer linkage to farmers is essential, such that research work is relevant to farmers' needs and research results are effectively disseminated.

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