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Evaluation of fish farmer management practices in Nyeri County, Kenya

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Abstract

This study evaluated management practices undertaken by fish farmers in Nyeri County. Data was collected from 117 fish farmers using semi-structured questionnaires to evaluate fish pond types, fish species kept, fish culture practices, fish pond water sources as well as fish pond drainage and treatment after harvesting. Most farmers in Nyeri Central (58.1%) used earthen ponds with 48.8% farmers in Tetu Sub County using liner ponds. Tilapia monoculture was the most popular fish culture method practiced by 79.7% and 55.8% farmers in Nyeri Central and Tetu respectively. Most farmers (84.6%) fertilized their ponds and were using commercial fish feeds (80.3%). Source of pond water was mainly rivers (63.2%) during the wet and dry seasons while a large proportion (76.9%) of farmers did not drain their ponds after harvesting. All the interviewed farmers were growing different types of crops (coffee, tea) and vegetables and also kept livestock (88.9%) in the two sub-counties. The most popular method for disposal of chemical containers was through burning.

Inadequate fish farmers' management practices may influence prevalence of fish parasites and types and quantities of chemical pollutants found in water and fish. This may adversely affect fish health and production.

Further studies are indicated to determine the economic losses associated with effects of inadequate fish farmer management practices in Kenya.

Keywords: Containers, Endo-parasites, Monoculture, Pollutants, Pond drainage, Sub counties.

1. Introduction

The explosive interest in fish farming stimulated by the Economic Stimulus Programme poses new challenges to the fish industry in Kenya ranging from poor knowledge of ideal management practices, nutritional requirements for optimum productivity, environmental pollution, biosecurity and spread of fish diseases (Munguti *et al.*, 2014) ^[1].

Farmers in Nyeri County are involved in fish farming as a way of producing high quality food rich in protein, either for subsistence or for the market. This is a way of improving the food security and earning extra income for families (Ngugi *et al.*, 2007) ^[2] thus reducing poverty.

Production of fish or fisheries products requires a set of technical and managerial skills. Mwamuye *et al.*, 2012^[3] in their study have observed that would-be aqua-culturists need specialized training in water quality management, aquatic weed control, parasite and disease control, nutrition and feeds, cultural techniques, marketing, and processing skills. Hishamunda (2001) ^[4] has observed that in rural parts of Côte d'ivoire aquaculture failed because the farmers lacked adequate management skills.

Orina *et al.*, (2014) ^[5] have observed that diseases, parasites and deformities reported in Nile tilapia and African catfish hatcheries were attributed to poor management levels since no proper systems are in place to enforce standards and ensure Best Aquaculture Management Practices.

Maina *et al.*, (2014) ^[6] have observed that fish farming management practices have not been characterized in Kenya and are still at a low level. They also noted that slow growth of fish in Mwea could only be attributed to poor pond management practices among other reasons.

The aim of the current study was to evaluate fish farmer management practices in Nyeri County since these practices influence the types and quantities of heavy metals, agrochemicals, diseases and parasites found in water and in farmed fish. This may adversely affect fish health and production.

2 Materials and Methods

2.1 Study area and data collection

The study was carried out in Tetu and Nyeri Central Sub-counties of Nyeri County, Kenya between July and August 2014. Nyeri County is situated Longitudes 36° 038' East and 37° 020' East; and Latitude 00° 380' South with temperature ranges between 12°C and 27°C and annual rainfall averages of 550mm in lowland and 1500mm in the highlands. The two sub-counties are in the agro-ecological zone II where farmers grow tea, coffee and other crops. Dairy, beef farming and fish keeping are also practiced.

A semi-structured questionnaire was designed, prepared, pre-tested and then a final version incorporating the pre-test results was produced. All questionnaires were administered through face-to-face interviews by the researcher with the help of four enumerators. The questionnaire gathered data on fish farmer management practices which included: fish production systems, species and culture method, pond fertilization, fish feed, pond water source, pond drainage after harvesting, crop and livestock enterprises on the farm and disposal methods for chemical containers.

2.2 Study design and sample size

In the study, households were the sampling units used. A list of fish farmers who owned at least a pond was obtained from the County Fisheries Officers in Nyeri County. The list of fish farmers formed the sampling frame. Samples were purposively drawn from Tetu and Nyeri Central sub counties based on the sampling frame. A total of 117 farmers were interviewed based on the formula by Yamane, 1967^[7].

2.3 Data analysis

By the end of the research period, 117 questionnaires had

been delivered. All the data was captured, stored analyzed using SPSS Version 17. A descriptive analyses (by use of means, modes, standard deviations, variance, percentages, and frequencies) to describe and document the state of affairs was done.

3 Results

3.1 Fish holding structures, species, culture method and type of feeds used

The most common type of fish pond was the earth type in Nyeri Central sub County at 58.1% Tetu Sub County had 46.5% farmers using earth ponds for fish culture (Table 1). The liner pond was more common in Tetu at 48.8% against 33.8% in Nyeri Central. A minimal number of fish farmers used concrete ponds in both sub counties (Nyeri Central 4.1%; Tetu 4.6%). Only 4.1% of those interviewed (4.1% from Nyeri Central) caught fish from dams.

Tilapia monoculture was the most popular fish culture method practised by 79.7% and 55.8% of the fish farmers in Nyeri Central and Tetu sub counties respectively (Table 1). Tetu had more farmers (41.9%) practising tilapia/catfish polyculture compared to Nyeri Central which had 14.9% while 5.4% and 2.3% practised catfish monoculture in Nyeri Central and Tetu sub counties respectively (Table 1).

Most of the farmers interviewed in Nyeri Central and Tetu sub counties were using commercial fish feeds (Nyeri Central 87.8%; Tetu 67.4%) while 12.2% and 32.6% were using other livestock feeds in Nyeri Central and Tetu sub counties respectively to feed their fish (Table 1). The other feeds included; dairy meal, bran, maize germ, pollard, kitchen remains, green vegetables, grass and sweet potato vines.

Table 1: Distribution of fish holding structures, species, culture method and feeds used by fish farmers in Nyeri Central and Tetu sub counties

| Sub County | | | | |
|---------------------------------|-----------|------------|-----------|------------|
| Nyeri central | | | Tetu | |
| Pond type | Frequency | Percentage | Frequency | Percentage |
| Earthen | 43 | 58.1 | 20 | 46.5 |
| Liner | 25 | 33.9 | 21 | 48.8 |
| Concrete | 03 | 4.0 | 02 | 4.7 |
| Other | 03 | 4.0 | 0 | 2.3 |
| Total | 74 | 100 | 43 | 100 |
| Fish species and culture method | | | | |
| Tilapia monoculture | 59 | 79.7 | 24 | 55.8 |
| Tilapia and catfish polyculture | 11 | 14.9 | 18 | 41.9 |
| Catfish monoculture | 4 | 5.4 | 1 | 2.3 |
| Total | 74 | 100 | 43 | 100 |
| Types of feed | | | | |
| Commercial feeds | 65 | 87.8 | 29 | 67.4 |
| Other feeds | 09 | 12.2 | 14 | 32.6 |
| Total | 74 | 100 | 43 | 100 |

3.2 Pond fertilization and its frequency

Majority of fish farmers fertilized their ponds in both Nyeri Central (81.1%) and Tetu (90.7%) sub counties (Table 2). A high proportion of respondents in both Nyeri Central (63.5%) and Tetu (72.1%) indicated that they fertilized their ponds using Cattle or sheep manure (Table 2). Other farmers used poultry manure (Nyeri Central 14.9%; Tetu 13.9%) and organic fertilizers (Nyeri Central 2.7%; Tetu 4.7%) in their ponds. Those farmers who never used fertilizer at all in their

ponds were distributed as follows: Nyeri Central had 18.9% while Tetu had 9.3% farmers.

Majority of fish farmers in Tetu Sub County (38.5%) fertilized their ponds only once since the pond was established with the rest fertilizing at a frequency of 1-2 months (12.8%), 3-4 months (17.9%) and 6-12 months (7.7%). Nyeri Central Sub County had majority of the farmers (56.6%) fertilizing their ponds at a frequency of 1-4 months (Table 2).

Table 2: Distribution of fertilization status, fertilizer types and the frequency of pond fertilization by respondents in Nyeri Central and Tetu Sub Counties

| Sub County | | | | |
|------------------------------|-----------|------------|-----------|------------|
| Nyeri central | | | Tetu | |
| Fertilization status | Frequency | Percentage | Frequency | Percentage |
| Fertilized pond | 60 | 81.1 | 39 | 90.7 |
| Did not fertilize pond | 14 | 18.9 | 4 | 09.3 |
| Total | 74 | 100 | 43 | 100 |
| Type of fertilizer | | | | |
| Cattle or sheep manure | 47 | 63.5 | 31 | 72.1 |
| Poultry manure | 11 | 14.9 | 06 | 13.9 |
| Organic fertilizers | 02 | 2.7 | 02 | 04.7 |
| Did not fertilize | 14 | 18.9 | 04 | 9.3 |
| Total | 74 | 100 | 43 | 100 |
| Pond fertilization frequency | | | | |
| 6-12 months | 07 | 11.8 | 03 | 7.7 |
| 4-6 months | 08 | 13.3 | 07 | 17.9 |
| 3-4 months | 17 | 28.3 | 09 | 23.1 |
| 1-2 months | 17 | 28.3 | 05 | 12.8 |
| 1-4 weeks | 06 | 10.0 | 00 | 0.0 |
| Once at start | 05 | 08.3 | 15 | 38.5 |
| Total | 60 | 100 | 39 | 100 |

3.3 Source of water for fish ponds

Table 3 below shows the sources of water used for fish farming in Nyeri Central and Tetu sub counties. Most fish farmers from both Nyeri Central (70.3%) and Tetu (51.2%) got water for their ponds from rivers and piped water (Nyeri Central 13.5% and Tetu 44.2%) during the wet season. Other sources of water during the wet season were water pans (Nyeri Central 2.7%; Tetu 0), shallow wells (Nyeri Central

2.7%; Tetu 2.3%) and roof catchment water (Nyeri Central 10.8%; Tetu 2.3%).

During the dry season, the farmers fed their fish ponds from rivers (Nyeri Central 64.9%; Tetu 53.4%), water pans (Nyeri Central 2.7%; Tetu 0), shallow wells (Nyeri Central 8.1% ; Tetu 0), roof catchment water (Nyeri Central 5.4%; Tetu 4.7%), and piped water (Nyeri Central 18.9%; Tetu 41.9%).

Table 3: Distribution of water sources for fish ponds during the wet and dry seasons in Nyeri Central and Tetu Sub Counties

| Sub County | | | | |
|-----------------------|-----------|------------|-----------|------------|
| Nyeri central | | | Tetu | |
| Source of water | Frequency | Percentage | Frequency | Percentage |
| During the wet season | | | | |
| Rivers | 52 | 70.3 | 22 | 51.2 |
| Water pans | 02 | 02.7 | 00 | 00.0 |
| Shallow wells | 02 | 02.7 | 01 | 02.3 |
| Roof catchment | 08 | 10.8 | 01 | 02.3 |
| Piped water | 10 | 13.5 | 19 | 44.2 |
| Total | 74 | 100 | 43 | 100 |
| During the dry season | | | | |
| Rivers | 48 | 64.9 | 23 | 53.4 |
| Water pans | 02 | 02.7 | 00 | 00.0 |
| Shallow wells | 06 | 08.1 | 00 | 00.0 |
| Roof catchment | 04 | 05.4 | 02 | 04.7 |
| Piped water | 14 | 18.9 | 18 | 41.9 |
| Total | 74 | 100 | 43 | 100 |

3.4 Fish pond drainage after harvesting

Majority of the respondents in the two sub counties did not drain their fish ponds after harvesting the fish (Nyeri Central 85.1%; Tetu 62.8%) (Table 4). A smaller percentage of

farmers (Nyeri Central 14.9%; Tetu 37.2%) either drained their ponds through the pond outlet (70.4%), pumping (18.5%), breaking pond dyke (7.4%), or through siphoning (3.7%).

Table 4: Distribution of drainage status of fish ponds after harvesting fish by respondents in Nyeri Central and Tetu Sub Counties

| Sub County | | | | |
|-------------------------------|-----------|------------|-----------|------------|
| Nyeri central | | | Tetu | |
| Pond drainage status | Frequency | Percentage | Frequency | Percentage |
| Never drains after harvesting | 63 | 85.1 | 27 | 62.8 |
| Drains pond after harvesting | 11 | 14.9 | 16 | 37.2 |
| Total | 74 | 100 | 43 | 100 |

3.5 Types and source of pollutants in fish pond water

3.5.1 Crops grown, fertilizer application, pesticide use and disposal of chemical containers

All the interviewed farmers (117/117) were growing different types of crops in different combinations ranging from cash crops (coffee, tea and macadamia), vegetables (onions,

capsicum, tomatoes, kales and cabbages), arrowroots, potatoes, maize, beans, bananas and napier grass. The major crops in Nyeri Central were vegetables, maize, beans and bananas in various combinations while most farmers in Tetu mainly grew cash crops, maize, beans and bananas in various combinations.

Crop fertilizer application was employed by 37.8% and 65.1% of the farmers in Nyeri Central and Tetu respectively (Table 5). Majority of the respondents in Nyeri Central (62.2%) were not applying crop fertilizers on their crops compared to Tetu where majority of respondents (65.1%) applied fertilizers on their crops. The types of crop fertilizers in use were

Diamonium phosphate, Urea, Calcium Ammonium Nitrate and Sodium Phosphorus Potassium.

A higher proportion of respondents did not use pesticides on their crops in Nyeri Central (68.9%) compared to Tetu (37.2%) where the majority (62.8%) were applying pesticides to control weeds and pests (Table 5). Pesticides used by respondents were fungicides, herbicides, insecticides and rodenticides.

All the respondents who used pesticides on their crops disposed off extra chemicals and their containers. Disposal methods employed were by: burning (60%), into a pit latrine (24.0%), burying (8.0%) and composite pit (8.0%).

Table 5: Distribution of use of crop fertilizers and pesticides by respondents in Nyeri Central and Tetu Sub Counties

| Sub County | | | | |
|-------------------------------------|-----------|------------|-----------|------------|
| Nyeri Central | | | Tetu | |
| Fertilizer and pesticide use status | Frequency | Percentage | Frequency | Percentage |
| Fertilizer use | | | | |
| Uses fertilizer on crops | 28 | 37.8 | 28 | 65.1 |
| Does not use fertilizer | 46 | 62.2 | 15 | 34.9 |
| Total | 74 | 100 | 43 | 100 |
| Pesticide use | | | | |
| Applies pesticides on crops | 23 | 31.1 | 27 | 62.8 |
| Does not apply pesticides on crops | 51 | 68.9 | 16 | 37.2 |
| Total | 74 | 100 | 43 | 100 |

3.5.2 Livestock enterprises and chemical use among respondents

A large proportion of the respondents (Nyeri Central 85.1%; Tetu 95.3%) owned a combination of livestock species ranging from cattle, sheep, goats, donkeys, pigs and rabbits in different combinations (Table 6). Majority of farmers in Tetu Sub County (88.4%) were using chemicals on their livestock

compared to Nyeri Central (45.9%) where majority (54.1%) were not applying chemicals on the animals (Table 6). The chemicals used on livestock were acaricides and dewormers.

Thirty three (45.8%) of those using acaricides or dewormers disposed of the chemical containers through burning, 5/72 by burying, 9/72 in a composite pit and 25/72 in a pit latrine.

Table 6: Distribution of livestock enterprises and chemical use by respondents in Nyeri Central and Tetu Sub Counties

| Sub County | | | | |
|----------------------------|-----------|------------|-----------|------------|
| Nyeri Central | | | Tetu | |
| Livestock ownership status | Frequency | Percentage | Frequency | Percentage |
| Owens livestock | 63 | 85.1 | 41 | 95.3 |
| Don't have livestock | 11 | 14.9 | 02 | 04.7 |
| Total | 74 | 100 | 43 | 100 |
| Chemical use on livestock | | | | |
| Applies chemicals | 34 | 45.9 | 38 | 88.4 |
| Does not apply chemicals | 40 | 54.1 | 05 | 11.6 |
| Total | 74 | 100 | 43 | 100 |

4 Discussion

A total of 117 fish farmers were interviewed in Nyeri County during the study. This study has shown that the most common type of pond was the earth pond in Nyeri Central sub County at 58.1% while almost an equal proportion of farmers in Tetu Sub County (48.8% and 46.5%) used both liner and earthen ponds respectively for fish culture. However, on average, earth ponds were the most common pond types compared to liner and concrete ponds. This study is in agreement with a similar survey in Western Kenya where Musa *et al.*, (2012) ^[8] found that most farmers had earthen ponds. Ngwili (2014) ^[9] found that the most common type of pond was the earth pond in Kiambu County (74.2 percent) and Machakos County (42.7 percent) among the Economic Stimulus Programme farmers. This finding is also consistent with that of Machena and Moehl (2001) ^[10] in a review of aquaculture pond types in Africa who noted that earth ponds are the dominant fish holding structures in Africa. Terchert-Coddington and Green (1997) ^[11] and Ramnarine (2000) ^[12] noted that the main fish

holding units were small earthen ponds.

Weeds growing in and around earthen ponds allow a conducive environment for propagation of fish parasites as well as the intermediate hosts of fish trematodes. In liner ponds, enhanced management practices such as proper stocking, proper environmental conditions, and weed control can reduce the propagation of fish parasites and pond pollution hence enhance fish health and production. Farmers are encouraged to use liner ponds since the liners can be used as a strategy of conserving the pond water as well as reducing fish pond water pollution and propagation of parasites.

During this study, it was noted that tilapia monoculture was practiced by 79.7% and 55.8% of the fish farmers in Nyeri Central and Tetu sub counties respectively with tilapia/catfish polyculture being done by a smaller percentage of farmers. This study collaborates with that of Ngwili *et al.*, (2015) ^[13] who found that 96.1% and 94.6% Economic Stimulus Programme of farmers kept tilapia monoculture in Kiambu and Machakos respectively while tilapia/catfish polyculture

was done by 9.1 percent and 12 percent of farmers in Kiambu and Machakos counties, respectively.

Clarias gariepinus (African catfish) is one of the most important fish species currently being cultured because of its resistance to parasites and diseases as opposed to tilapia (*Oreochromis niloticus*) which consume a wide variety of feed materials and feed low in the food chain (De Silva, 1993)^[14]. Polyculture of tilapia with catfish is at times done to control the uncontrolled breeding of tilapia.

It was observed during this study that most of the farmers interviewed in Nyeri and Tetu sub counties were using commercial fish feeds to feed their fish (Nyeri Central 87.8%; Tetu 67.4%) although a smaller number of farmers (12.2% and 32.6%) in Nyeri Central and Tetu sub counties respectively were using other livestock feeds to feed their fish. The other feeds included; dairy meal, bran, maize germ, pollard, kitchen remains, green vegetables, grass and sweet potato vines. This study is in agreement with observations by Ngwili (2014)^[9] who observed that all the farmers in Kiambu and Machakos counties used complete or formulated commercial feeds for feeding the fish. He also found that kitchen left overs and vegetable residues were also used as fish feed. Non processed fish feeds may contain substances that can act as pollutants of fish pond water, the medium in which fish are fed and perform all their body functions. Pathogenic activity by ecto-and endoparasites of fish, can be influenced by water pollution (Khan and Thulin, 1991)^[15] and there is a strong relationship between high parasites' prevalence and fish condition due to improper feeding. A poor state of fish health is the result of enhanced effects of the parasites on fish harmed by the direct effects of pollution (Svobodová *et al.*, 1993)^[16].

Majority of fish farmers in both Nyeri Central (63.5%) and Tetu (72.1%) sub counties indicated that they fertilized their ponds using Cattle or sheep manure with few farmers using poultry manure and organic fertilizers. These findings are consistent with results by Ngwili (2014)^[9] who reported that farmers in both Kiambu and Machakos counties used farm yard manure for pond fertilization with only few farmers using both manure and chemical fertilizers. Majority of fish farmers in Tetu Sub County (38.5%) fertilized their ponds only once since the pond was established with most Nyeri Central Sub County farmers (56.6%) fertilizing their ponds at a frequency of 1-4 months. Results of this study agree with Ngwili (2014)^[9] who observed that farmers in Kiambu county fertilized their ponds more frequently compared to those in Machakos county with ponds in Kiambu County having green water due to proper fertility management.

Fish pond fertilization is a necessary prerequisite for phytoplankton growth, which is the natural feed for the fish. Over fertilization leads to high turbidity of the water which is not good for fish rearing because it leads to gill damage (Lloyd 1987)^[17].

The major source of water for most fish farmers from both Nyeri Central and Tetu sub counties was from rivers and piped water during both the wet and dry seasons. Rivers formed a greater percentage of water sources in the two sub counties because there are permanent rivers and streams traversing through them. This study found that all the earth ponds were constructed on a wetland due to closeness to the water source mainly rivers.

The running water may carry with it infective larvae that may infect fish. All liner ponds were supplied with water by a tanker which was drawn from rivers therefore bearing the same risk of transmitting parasites to fish. River water may be

contaminated with heavy metals and agrochemical pollutants which may adversely affect fish health and production. Good management of water quality reduces stress to the fish which occurs when fish are subjected to poor environmental condition and greatly reduces the risk of fish diseases and parasites (Kamundia, 2011)^[20].

This study found that majority of the respondents in the two sub counties did not drain their fish ponds after harvesting their fish. Only a smaller percentage of farmers either drained their ponds through the pond outlet, pumping, breaking of pond dyke, or through siphoning. These results consent with those of Ngwili *et al.*, (2015)^[13] who reported that 86 and 65 percent of farmers in Kiambu and Machakos counties respectively did not drain their ponds after harvesting. When the fish ponds are not drained for long periods, it is likely that organic wastes will accumulate resulting to decreased amount of dissolved oxygen and may lead to death of fish. This practice predisposes the development and re-infestation of fish by parasites since their life cycle is not broken as happens after emptying the fish ponds. Ngugi *et al.*, (2007)^[2] observed that pond drainage is a key aspect of pond management since it influences the water quality which may affect dissolved oxygen, fish health and primary productivity of the pond. Draining should be done at the end of each production cycle to get rid of accumulated chemicals which may be toxic to the fish. Poor fish pond management practices such as lack of pond emptying after fish harvesting, low fish pond water levels and pollution allows a favourable environment for propagation of fish parasites. Prolonged exposure to these conditions predisposes fish to infestation by fish diseases and parasites.

All the interviewed farmers (117/117) were growing different types of crops in different combinations ranging from cash crops, vegetables, arrowroots, potatoes, maize, beans, bananas and Napier grass. Results from the study showed that fish farmers from Nyeri Central mainly grew vegetables in their gardens. Nyeri Central Sub County is an urban area while Tetu Sub County is rural based where farmers have larger farms and practice cash crop farming besides fish farming. These results show similarity with those of Ngwili (2014)^[9] in Kiambu and Machakos counties where the major crops grown in the two counties were maize, beans, vegetables, fruits and cash crops (coffee and tea). The chemicals used in crop production in the two sub counties were fertilizers (Diamonium phosphate, Urea, Calcium Ammonium Nitrate and Sodium Phosphorus Potassium) and pesticides (fungicides, herbicides, insecticides and rodenticides).

Chemicals (heavy metals and agrochemicals) may enter fish ponds from natural or human activity sources, including industrial or domestic waste water, application of pesticides, inorganic fertilizers, storm runoff and leaching (Yilmaz, 2009)^[18]. Mixing and loading pesticides in areas where residues or run-off are likely to threaten surface waters are potential sources of contamination. Improper cleaning or disposal of remaining agrochemicals, their containers and wrappings do contribute to environmental pollution. Studies have reported that only 5% of the sprayed chemicals actually reach the targeted organisms, with the remaining 95% drifting to surrounding areas and eventually becoming an environmental contaminant, (Panagiotis and Weili, 2008)^[19].

The respondents in the two sub counties disposed remaining agrochemicals and their containers and wrappings through burning, into a pit latrine, burying or into a composite pit hence these chemicals did not find their way into fish ponds.

This study found that a large proportion of the respondents

(85.1% and 95.3% in Nyeri Central and Tetu sub counties respectively) owned a combination of livestock species ranging from cattle, sheep, goats, donkeys, pigs and rabbits in different combinations. This study is in agreement with Ngwili (2014) ^[9] who reported that the main livestock species kept in Kiambu and Machakos counties county were dairy cattle, goats, poultry, pigs and rabbits (66 percent and 83 percent of farmers in Kiambu and Machakos counties, respectively).

The chemicals used in livestock in the two sub counties were acaricides and dewormers. This was similar to results by Kamundia (2011) ^[20] who reported use of acaricides and other chemicals to control parasites in animals by fishermen in Homa Bay and Sindo of Lake Victoria. The disposal of remnant or expired agrochemicals and the agrochemical containers/wrappers is one of the ways chemicals are introduced into the environment.

The respondents in the two sub counties disposed remaining acaricides and dewormers and their containers through burning, burying, in a composite pit or in a pit latrine thus a low probability of these chemicals entering into the fish ponds.

5. Conclusions and recommendations

Fish farmers' management practices influence prevalence of fish parasites and types and quantities of heavy metals and agrochemicals found in water and in farmed fish. Further studies are indicated to determine the economic losses associated with effects of inadequate fish farmer management practices in Kenya.

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