Attitudes and practices of farmers with regard to pesticide use in NorthWest Ethiopia

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Abstract: This paper studies the practice of synthetic chemical use among farmers and its possible occurrence as residue in fish foods in North-West Ethiopia. Cross-sectional study design was carried out from January to December 2018. A multistage sampling technique embedded with simple random sampling was employed for the selection of sampling units. The data were collected through in-depth interviews and observations of farmers. Data entered and analyzed by using SPSS version 20. The results showed that farmers applied chemicals indiscriminately and inappropriately on their farm, using unsafe storage facilities, ignoring risks and safety instructions. Consequently, farmers respond that insecticides and herbicides were used up to 100% and 96.4% of their farms, respectively. Most of the farmers (80.16%) of the study area have poor attitudes and practices of pesticide usage. Multivariable analysis showed, illiterate educational level; Adjusted Odds Ratio [AOR] = 3.39; 95% CI: 1.7, 6.77; Land holders situation (AOR = 1.8, 95% CI: 1.52, 2.9) has been formally not trained about pesticides usage (AOR = 2.97, 95% CI: 1.06, 8.37) and not read pesticide labels (AOR = 3.69, 95%CI: 1.62, 13.64) were significantly associated with possible poor attitude and practice of pesticide contamination. We conclude that there are high possibilities of chemical residues affects fish and occurring in food products (in milk, meat, fish, vegetable and fruit) that may have a public health risk in the study area. Therefore, one health intervention is required.

ABOUT THE AUTHOR
Birhan Agmas Authors’ key research project includes research in general chemical and microbiological contaminants of fish food and their public health significance. This current paper is a part of this project activity that persistence organochlorine pesticide contamination of aquatic environment their effects on fish and public health. The current paper contributes to findings recorded in the field of environmental toxicology, especially attitudes and practices of farmers with regard to pesticide use and their possible consequences to public health.

PUBLIC INTEREST STATEMENT
Farmers applied pesticide chemicals indiscriminately and inappropriately on their farm, using unsafe storage facilities, ignoring risks and safety instructions. Most of the farmers of the study area have poor attitudes and practices of pesticide usage. Illiterateness, the situation of land rent holders, the lack of formal training on pesticide use and the failure to read pesticide labels were the leading factors for having possible poor attitude and practice of pesticide usage of farmers. There are high possibilities of chemical residues that may affect fish and occurring in food products (in milk, meat, fish, vegetable and fruit). Thus may have a public health risk in the study area. Such information is important for appropriate imminent intervention of development practitioners, decision makers and this area issue stockholders.
1. Introduction

Pesticides are chemicals with persistence, bioaccumulation through the food web, and potential negative impacts on humans and animals (Donaldson et al., 2010). Chemicals designed to kill, reduce or repel pests such as insecticides, rodenticides, fungicides, herbicides, wood preservatives, insect repellents and fumigants are used extensively to improve agricultural production. Their lethal nature and non-targeting of a specific nature causes them to poison other organisms, including different birds, fish species, animals, and humans. When chemicals are improperly implemented because of a lack of appropriate knowledge about their calibration, they can cause problematic effects on the environment and biota. Excessive use contaminates the environment and thus harms the ecosystem once it crosses the threshold limit in the system (Khodadadi et al., 2012; Srivastava et al., 2010). Mainly organochlorine pesticides are poorly hydrolyzed and biodegrade slowly in the environment. Therefore, these compounds are persistent in food chains and are readily accumulated in animal tissues, especially in adipose tissue due to their lipophilic nature (Donaldson et al., 2010).

Pesticide contaminant is a potentially harmful chemical substance of anthropogenic or natural origin, which may be present in food following indiscriminate and inappropriate use on farm (Srivastava et al., 2010). Foods from animals, vegetables, fruits and fishes can potentially be contaminated with one or more of the thousands of manufacturing pesticides, which are used in society at the farm level. However, less attention has been paid to residues of potentially hazardous pesticides present in food (Fair et al., 2018).

Humans, animals and fish acquire risk by ingesting contaminated foods that have a residue level higher than the maximum residue limits and acceptable daily intake (WHO/FAO, 2009). An immediate effect of pesticides is killing or injuring fish, human and other animals through the food chain (Akueshi et al., 2003). Number of studies on both humans and animals provide strong evidence of the toxic potential of exposure to pesticides; If food contaminated by them is ingested (Ghasemi & Karam, 2009; Yazgan & Tanik, 2010). Long-term health adverse effects such as increased likelihood include reproductive failures like (infertility), respiratory failures, kidney failure, nervous defects like depression, birth defect, endocrine disruption, immune system dysfunction, and cancer (prostate cancer, leukemia) (E. D. Okoffo et al., 2016; Yazgan & Tanik, 2010). Studies also showed that pesticides have strong potential to cross placental barriers even at minute concentration and cause serious neonatal damage (Yazgan & Tanik, 2010).

Pesticide levels are generally declining in developed countries with regard to the environment, but are increasing in developing countries because they are still in use for agricultural and public health purposes (Sadasiviah et al., 2007; Thompson et al., 2017; WHO, 2007). In Ethiopia, studies in the Rift Valley region have revealed contamination of the environment (sediment and fish) by pesticides (Deribe et al., 2011; Yohannes et al., 2013). It is known that a large portion of the pesticide applied in an area reaches into healthy environmental components such as ponds, lakes and rivers, where it gradually accumulates into other organisms (Srivastava et al., 2010).

There is still an increasing trend in pesticide use for improving agricultural production around Lake Tana, where it is a densely populated area with various agricultural activities; with three cropping times per year. Consequently, high concentrations of pesticides can be found in the environment and fish foods in our study area. In Ethiopia, studies assessing the environmental contamination of pesticides are scarce; none has been done in our study area. Therefore, this study was aimed to assess the practice and attitude of farmer’s pesticide usage and its risks to fish and public health in North Western Ethiopia.
2. Materials and methods

2.1. Study area
The study was conducted in NorthWest Ethiopia. Districts those are around Lake Tana were included in the study. Lake Tana is situated on a basaltic plateau in the North-Western highlands of Ethiopia. The lake is the headwater of the Blue Nile River. It is an oligomesotrophic shallow lake with an average depth of 8 m and a maximum depth of 14 m. It is turbid, well mixed and has no thermocline (Eshete et al., 2004). The catchment area of Lake Tana has a dendritic type of drainage network. Lake Tana and its surrounding districts is depicted below (Figure 1). Lake Tana has a temperature of 20.2–26.9°C, total dissolved solids 163.6 mg/l; PH 6.8–8.3 and conductivity 132.8 µS Cm-1 (Eshete et al., 2004). Seven permanent and 40 small seasonal rivers supply/contribute water to the lake. The main tributaries of the lake are the Gilgel, Abay, Megech, Gumara and Ribb Rivers. Together, they contribute more than 95% of the total annual inflow (Lamb et al., 2007). The lake is also used for commercial fishing. Lake Tana receives a wide variety of waste from agricultural activity around this area, including insecticides, fungicides and herbicides. Most farmers around the Lake Tana area used synthetic pesticides to control pests on vegetables and field crops under irrigation and rain-fed conditions.

Figure 1. Map of Lake Tana and surrounding study area (Tegegne et al., 2017).
2.2. Study population
All people live around the Lake Tana administrative districts. All smallholder farmers with an adult population (>18 years of age) live in randomly selected administrative areas around Lake Tana. The study unit is composed of one adult (>18 years of age) from each selected household/family who was included in the study by chance and in an investigative interview. Inclusion criteria are for a person (>18 years of age) who has resided in the selected household/family for at least one year.

2.3. Study design
The cross-sectional study design was carried out from January 2018 to December 2018.

2.4. Sampling method
A multi-stage sampling technique embedded with simple random sampling was employed for the selection of sampling units. Four of the districts were selected by simple random sampling techniques. Sampled administrations were at Gorgora Rural Administration in Dembia District, at Nabega Rural Administration in Fogera District, at Agidikirga Rural Administration in Lebokomkem District and at Korata Rural Administration in Dera District; Lake Tana Basin, Ethiopia. The number of households included in each administrative area was determined by a proportional distribution based on the total number of households found in each administrative area. An individual household in the selected administrative area was selected using a simple random sampling technique. One adult (>18 years of age) from each selected household/family was further selected and interviewed. If in a selected household with more than one adult (>18 years of age) in one household, only one person was selected using the lottery method. Perhaps no eligible candidate was identified in a selected household or the selected household is closed. Even after revisiting, the interviewer went to the next household in the clockwise direction until receiving an eligible person.

2.5. Sample size determination
The sample size was determined by using a 95% confidence interval and 5% desired level of precision. Because there were no previous studies conducted on Pesticide use malpractice in the study area, the expected prevalence was taken as 50% and the size was determined by the formula for the infinite population given below (Daneil, 2009).

\[
n = \frac{1.96^2 \times P_{exp}(1 - P_{exp})}{d^2}
\]

where \(n\) = required sample size, \(P_{exp}\) = expected prevalence, \(d\) = desired absolute precision.

Based on the above given formula, the total sample size was expected to be 384. However, for representativeness of our sample adding 44 samples for non-response rate the required sample sizes rise into 428.

2.6. Data collection instrument and procedures
The questionnaire was used to interview smallholder farm owners. The questionnaire consisted of a list of knowledge and perception items, which were developed on the basis of previous pesticide use studies (Adesuyi et al., 2018; Essumang et al., 2009; Yared et al., 2016). The questionnaire consisted of four parts; (a) Questions on socio-demographic data on pesticides used; commonly used insecticides, fungicides, herbicides and rodenticides were considered. These pesticides are assessed for their use and possible perceived conditions of risk of ecosystem contamination, (c) questions to determine the behavior and intent of respondents in pesticide use and handling, (d) questions to determine pesticide regulation and monitoring practices, and (e) knowledge and perception of the environmental and public health effects of pesticides. The questionnaire was translated into the Amharic language to be close to the concept of the original questionnaire. The Amharic version questionnaire was used for data collection through open and close-ended questions. Back translation from Amharic to English was done by a bilingual translator. After that, the translated version was discussed with researchers to reword some statements to be ready for
testing. The final translated version was pretested and piloted with 30 farmers to get feedback on the clarity of the questions. Subsequently, the face and content validity of the questionnaire was verified by pesticide professionals who are experts in the field. The final version was then completed and recommended for study. A face-to-face interview was conducted by researchers to obtain data from all participants. The questionnaire was completed by researchers during the interview. Close observation of cereal and pulse crop farms, vegetable and fruit and cash crops that are coffee and khat farms, were randomly selected visited during smallholder farmers' spray.

2.7. Data entry, management and analysis
Data were entered and cleaned by EPI-InfoV.3.5.3; it is cleaned, edited and analyzed by using SPSS version 20 and exported by state transfer. Data cleaning was performed to check for accuracy and consistencies and missed values and variables. Any logical and consistency error identified during the data entry was corrected after the revision of the originally completed questionnaire. To explain the study population with relevant variables descriptive statistics were used. A bivariate logistic regression model was used to test the association of variables. Then which p-value <0.025 was subjected to a multivariable logistic regression model to manage confounders. The strength of the association was determined based on odds ratio and confidence interval at 95% was used to identify the main associated variable.

2.8. Ethical consideration
The study was granted an exemption from requiring ethics approval from the College of Agriculture and Environmental Science, Research and Review Committee. The purpose and importance of the study were explained to the participants. Data were collected after full informed verbal consent was obtained and confidentiality of the information was maintained by using a unique code.

3. Results

3.1. Socio-demographic characteristics of the key informants
Of 423 study subjects, 302 (71.45%) were male while 121 (28.61%) were female. Of the respondents 206 (48.7%) were in 18–24 years age group, 134 (31.68%) were in the age group of 25–39 years and 83 (19.62%) were in the age group of 40–54 years old (Table 1). The average age of the study subjects was 31 with SD± 8 years, with minimum and maximum value 21 and 49 years, respectively.

From the total 423 respondents, 177 (41.85%) were found unable to read and write, 161 (38.05%) can read and write only, 44 (10.40%) learned primary level/elementary education, 41 (9.70%) were secondary level and above education. Concerning their farm size/area, most of the study subjects 295 (69.74%) had less than 1 ha, around 128 (30.26%) has greater than 1 ha for farming. Land tenure situation; landowner 258 (61%) and remain 165 (39%) are landholder by rent for farming. The farmers who use of pesticide frequently showed that three and more times was 21 (4.96%); most farmers 219 (51.77%) use pesticide two times per year and the remains 183 (43.26%) use once. The farmers expressed that three and more times they use in khat and fruits farms whereas two times use mostly in residual moisture crops such as check pea and grass pea.

3.2. Commonly Used pesticides in small holder farms
As Table 2 showed the assessment revealed that farms use three or more pesticide chemicals. Among these, insecticides sprays (100%), herbicide (96.4%) and fungicide drugs (65.72%) were the most frequently applied in their agricultural crop. These pesticides were mainly used for the treatment of insect infestation, weed control and fungus treatments in their agricultural crops. More specifically; farms in the area use different insecticides (Diazinon 60% EC, Endosulfan 35% EC, Dimethoate 40% EC and Malathion 50% EC) to control insects. The most common insects they describe to control in the area were aphids, African ball worm, thrips, termite, spider mites, stock borer, fruit borer and soil born insects. Anti-fungal chemicals (Mancozeb 64% WP, Radiomil, Apron
Star 42WS and Tilt 250 EC) were used by farmers to treat fungal infections. The fungal infections are late blight, powdery mildew, leaf spot, downy mildew, purple blotch, pepper rot root, and powdery mildew. The study also showed that farmers in the study area use such as 2–4D Amine (96.4%) and Premagram gold (17.4%) as herbicides. Zinc Phosphide (14.18%) as the sole rodenticide (Table 2). Some of the farmers use pesticides in stores to control storage pest. The main crops they depicted that the implements pesticides in filed are cabbage, onion, tomato, pepper, maize, chickpea, grass pea, wheat, teff, fruits and khat.

3.3. Farmers’ knowledge, attitude and understanding about pesticide
Table 3 shows the percentages of farmers who had awareness of the health risk of pesticides. The most 80.61% of the farmers had not received any training, in pesticide use and safety. The remaining 19.39% had been given short-term training and hear about pesticide by other means. Most farmers strongly agreed on the negative side effects of pesticides on human health (62.65%), animal health (39.48%) but not on fish only 15.13%. They also explained that the pesticide had positive effect on high crop yield of 69.98%. Most 81.32% of the farmers were found unable to read and understand the meaning of labels due to the language barrier (English or French) foreign to
Table 2. Summary of the assessments of pesticides (herbicides, fungicides and rodenticides) used in farms, around Lake Tana (n = 423)

| Pesticides     | Frequency | Percent (%) |
|----------------|-----------|-------------|
| Insecticides*  | 423       | 100         |
| Endosulfan 35%EC | 302       | 71.39       |
| Diazinone 60%EC | 423       | 100         |
| Diamethlate 40%EC | 169       | 39.95       |
| Malathion 50%EC | 215       | 50.82       |
| Deltamethrine 25 g/l | 7         | 1.65        |
| Anti-fungal*   | 278       | 65.73       |
| Mancozeb 64% WP | 245       | 57.92       |
| Rediomil gold 68WS | 111       | 26.24       |
| Apron Star 42WS | 17        | 4.02        |
| Tilt 250 EC    | 8         | 1.89        |
| Herbicides*    | 407       | 96.4        |
| 2-4D Amine     | 407       | 96.4        |
| Primagram Gold | 73        | 17.26       |
| Palace         | 2         | 0.47        |
| Rodenticide    |           |             |
| Zinc phosphide | 60        | 14.18       |

*Stand for multiple choices were possible; Source: filed survey 2018

3.4. Farmers’ practices on use, storage and disposal of pesticides

With regard to pesticide use practices, the storage and disposal of empty containers; Table 4 shows that most farmers in the study area had poor practices. The majority of 60.9% reported that pesticides were stored in the living houses. A worrying 25.77% of the farmers responded that they store pesticides in an animal house. Only 0.13% of the respondents’ perceived that the pesticide should be locked in a chemical store. Most respondents were not concerned about over-dosing; 72% of them responded that they apply the leftover solution to crops reputably. Others disposed of the solution in the field and in the water body.

Across the study area, empty pesticide containers thrown at farms or reused at home for other purposes was the most commonly practiced method as reported by the majority of respondents. This was followed by participants who reported incinerating/burying on the farm in empty containers.

3.5. Factors associated with the attitude and practice of farmers towards unsafe use of pesticides

The results of the bivariate logistic regression analysis show that education levels, farm size (ha), land tenure status, cultivated agricultural products, formal training on pesticides usage and labeling of pesticides have been identified as being significantly associated with poor attitudes and practices of pesticide contamination. With regard to multiple variable logistic regression analysis, the only independent variables which were still significantly associated with the possible poor attitude and practice of pesticide contamination include educational level, land tenure situation, formal training on pesticides and reading pesticides labels. The odds of illiterate respondents were 3.39 times more likely to have a poor attitude and practice about pesticide contamination than secondary and above-educated respondents (AOR = 3.39, 95% CI: 1.7, 6.77). On the
### Table 3. Farmers’ knowledge, attitude and understanding about pesticide (n = 423)

| Variables                                      | Frequency | Percent (%) |
|------------------------------------------------|-----------|-------------|
| **Pesticides affect human health**             |           |             |
| Strongly agree                                 | 265       | 62.65       |
| Agree                                          | 72        | 17.02       |
| Disagree                                       | 61        | 14.42       |
| Strongly disagree                              | 25        | 5.91        |
| **Pesticides affect livestock**                 |           |             |
| Strongly agree                                 | 167       | 39.48       |
| Agree                                          | 21        | 4.96        |
| Disagree                                       | 154       | 36.41       |
| Strongly disagree                              | 81        | 19.15       |
| **Pesticides affect the environment (fish)**    |           |             |
| Strongly agree                                 | 64        | 15.13       |
| Agree                                          | 62        | 14.66       |
| Disagree                                       | 221       | 52.25       |
| Strongly disagree                              | 76        | 17.97       |
| **Pesticides are indispensable for high crop yield** | | |
| Strongly agree                                 | 159       | 37.59       |
| Agree                                          | 137       | 32.39       |
| Disagree                                       | 96        | 22.70       |
| Strongly disagree                              | 31        | 7.33        |
| **Read pesticides labels**                     |           |             |
| Yes                                            | 79        | 18.68       |
| No                                             | 344       | 81.32       |
| **How do pesticides enter the human body?**    |           |             |
| Dermal                                         | 6         | 1.42        |
| Inhalation                                     | 38        | 8.98        |
| Oral                                           | 201       | 47.52       |
| Eye contact                                    | 178       | 42.08       |
| **Do you know pesticides are banned or restricted for use?** | | |
| Yes                                            | 321       | 57.89       |
| No                                             | 102       | 42.11       |
| **Do you know the reasons for banning/restricting pesticides?** | | |
| Highly toxic                                   | 111       | 26.24       |
| Not effective                                  | 54        | 12.77       |
| Expensive                                      | 223       | 52.72       |
| Don’t know                                     | 35        | 8.27        |
| **Have been taken formal training on pesticides** | | |
| yes                                            | 82        | 19.39       |
| No                                             | 341       | 80.61       |

(Continued)
other hand, respondents whose land tenure situation; land holders were 1.8 times more likely to contaminate the environment than (AOR = 1.8, 95% CI: 1.52, 2.9). Similarly, respondents who couldn’t read pesticide labels were 3.69 times more likely to have poor pesticide contamination attitude and practice than who can read pesticide levels (AOR = 3.69, 95% CI: 1.62, 13.64). Not taking formal training on the use of pesticides has been undertaken as a factor associated with the poor attitude and practice of pesticide contamination in the environment. The odds of informants who haven’t taken formal training on pesticide use were 2.97 times more likely to have pesticide contamination those who have taken formal training (AOR = 2.97, 95% CI: 1.06, 8.37).

4. Discussion
In order to investigate the presence of pesticide residue in the foods of fish origin, mainly where misuse of pesticides is growing, knowing the commonly used synthetic chemicals by farmers in an aquatic basin and assessing their insight about pesticide residue are very essential. The results of this assessment showed that the majority of farmers used insecticide spray (100%) to control of insects, fungicide chemicals (65.72%) and followed by herbicides (96.4%). Similarly, for our findings, studies of high pesticide use trends were conducted by Mengistie et al., (B. T. Mengistie et al., 2017) in the central rift valley (97 %) and Amera and Abate (Amera & Abate, 2008) Central Ethiopia showed that the majority (94.3%) of the farmers used pesticides as part of their agricultural input. This finding was different from the lower prevalence of pesticides used by the farmers in the North Shewa area were insecticides (37.6%), fungicides (17.8%) and herbicides (31.5%) and with the remaining 3.1% being rodenticides (Hiluf & Ayalew, 2015). In the present study, the pesticides used by farmers were insecticides (Diazinon 60% EC, Endosulfan 35% EC, Dimethoate 40%EC, Malathion 50% EC and Deltamethrin 25 g/l), antifungals (Mancozeb 64% WP, Rediomil Gold 68WS, Apron Star 42ws, and Tilt 250EC), herbicides (2–4D Amine, Primagram gold and Palace) and rodenticides (Zinc Phosphide) which are consistence with the studies conducted by Tekbew and Getachew, (Tebkew & Getachew, 2015) and Jallow et al., (Jallow et al., 2017). The threat caused by Endosulfan and Diazinon 60% EC is of great concern. Endosulfan and Diazinon 60% EC remains in the environment for long periods and bio-accumulates in plants and animals, causing contamination of food consumed by humans (Briz et al., 2011). Run-off and leaching potential of Diazinon 60% EC and Endosulfan are very high (Agrawal et al., 2016; Teklu et al., 2016) thus pesticide residues can occur in fish and Lake Tana in our study area since they are used indefinitely. This finding is also consistent with commonly used pesticides in farms, suggesting a high potential for occupational and environmental risks to occur (Negatu et al., 2016). Hence, the possible occurrence of pesticide residue in fish is high and can also be a possible residue effect on public health which agrees with the assessment and laboratory result done in and around Lake Ziway, Ethiopia (Teklu et al., 2016).

| Variables                        | Frequency | Percent (%) |
|----------------------------------|-----------|-------------|
| Informed about the proper use of pesticides |           |             |
| Informed                         | 241       | 57.1        |
| Non informed                     | 182       | 43.03       |

Source of information*

| Source of information*          | Frequency | Percent (%) |
|---------------------------------|-----------|-------------|
| Pesticides sellers             | 175       | 41.37       |
| Local DA experts               | 35        | 8.27        |
| Health care providers          | 31        | 7.33        |

*Multiple choices were possible
Table 4. Farmers’ practices on use, storage and disposal of pesticides around Lake Tana (n = 423)

| Variable                                                                 | Frequency | %     |
|--------------------------------------------------------------------------|-----------|-------|
| **Store of pesticides**                                                  |           |       |
| Open shed just for pesticides                                           | 2         | 0.47  |
| Locked chemical store                                                    | 55        | 0.13  |
| Living house                                                             | 257       | 60.9  |
| Animal house                                                             | 109       | 25.77 |
| **Mixing pesticides/dose according to the recommendation**              |           |       |
| yes                                                                      | 302       | 71.39 |
| No                                                                       | 121       | 28.61 |
| **Place of pesticide mixing**                                           |           |       |
| Near a river/lake water sources                                          | 286       | 67.61 |
| In the field                                                             | 92        | 21.75 |
| In home                                                                  | 45        | 10.64 |
| **Recommended frequency of spraying**                                   |           |       |
| Yes                                                                      | 22        | 5.20  |
| No                                                                       | 401       | 94.80 |
| **Use personal protective during spray**                                 |           |       |
| Yes                                                                      | 32        | 7.57  |
| No                                                                       | 391       | 92.43 |
| **What do you do with the unused leftover (mixed, diluted) pesticides?** |           |       |
| Dispose of in the field                                                  | 107       | 25.29 |
| Dispose into                                                             | 12        | 2.84  |
| Apply on crops reputedly                                                 | 304       | 72    |
| **What do you do with old pesticides stocks?**                          |           |       |
| Return to retailer                                                       | 2         | 0.47  |
| Apply on crops                                                           | 265       | 62.65 |
| In the field                                                             | 150       | 35.46 |
| Buy the only amount needed                                               | 6         | 1.42  |
| **Empty pesticide containers**                                           |           |       |
| Discard on-farm                                                          | 181       | 42.8  |
| Incinerate/bury on-farm                                                  | 5         | 1.18  |
| Reuse for other purposes                                                 | 237       | 56.03 |

The assessment of farmers’ awareness of the possible effects of pesticide residues on human health, livestock and water body organisms/fish showed that 79.67%, 44.44% and 29.79% of respondents had awareness and information on the side effects of pesticide residues, respectively. However, a very small proportion of farmers (19.39%) receive formal training on the proper use of pesticides. Despite the fact that farmers are aware of the human health effects of pesticide residue, they believe that increasing agricultural production (70%) is possible only through the indiscriminate addition of pesticides or more concerned with the high economic returns of their crops than with their own health (B. T. Mengistie et al., 2017). Sources of information on pesticide hazards for farmers were pesticide sellers (41.37%), local development agents (8.27%) and health-care providers (7.33%). The low extension addressing of local
development experts and health-care providers may be the fear that farmers may not use future pesticides in crop and household spray for malaria prevention. In addition, the lack of information/technical knowledge, motivation, interaction and capacity (human, financial and material) of local actors contributes to weak agricultural and health extension systems in supporting smallholder farmers in their pesticide use practices (B.T. Mengistie et al., 2016).

In Ethiopia, there is neither a standard system that accepts and collects expired, unwanted or unused pesticides and pesticide containers nor established recycling systems for disposal and there is also a huge gap between the policy and its implementation (Loha et al., 2018). The study showed that storing pesticides in a living house is the most commonly practiced means of storing pesticides in farmers: 60.9%. The remaining 26% of farmers reported storing pesticides in an animal house, and only 13.1% of the sample saw the health risk and they locked in the chemical store. Another poor practice in the study area was to discard pesticide containers. As a result, 42.8% of respondents had abandoned the farm, 56.03% had a reuse for another purpose in the house and 1.18% had only incinerates and/or buries on the farm. Similar to this finding; studies conducted in Ghana report similar reuse for other home purposes (ED Okoffo et al., 2016).

Most respondents were not concerned about overdosing, unused leftover (mixed/diluted) pesticides, and 72% reported that they applied leftover solutions to crops reputedly. Others disposed of the solution on field (25.29%) and on the water body (2.84%). Farmers in the area mixed their pesticides near river/lake water sources (67.61%), in their crop field (21.75%) and at home (10.64%). The overall average of the eight variables measured for poor pesticide use is 91.71%, with 95% CI (86.41-94.71%) and only (8.29%) of farmers responding to good practices in pesticide residue use, storage and disposal. Similar to our finding, the study conducted in Sudan by Awad et al. (Awad et al., 2018) showed that (92.8%) of farmers showed poor practices regarding the disposal of pesticides and their empty containers.

In line with our study, other different scholars report poor pesticide use practices in different parts of Ethiopia (Amera & Abate, 2008; Negatu et al., 2016). This high level of poor practice in our study area could have a high risk of pesticide residue contamination in Lake Tana, which could have a detrimental health effect on fish and humans. Pesticides are introduced into fish primarily through contaminated water used for household and public purposes (Sankhla et al., 2018). Pesticide residues are a source of water contamination. Since pesticides leach and drain into lakes through flooding and rivers, this Lake Tana water is usually used to harvest fish by residents. This is of particular concern, especially in the town of Bahir Dar, Amhara regional state, as it is Ethiopia’s largest lake for fish production. The authors found that pesticides’ entry into the water through leaching and drainage causes these chemicals to be proven to cause adverse impacts on human health, fish and their environment (Agrawal et al., 2010). Fish are the highest estimated risk category and are taken as representative for the overall risk for all aquatic organisms within the grid (Teklu et al., 2016). As pesticides have a high effect on fish, eventually humans also take up pesticides through the food chain (Fair et al., 2018).

With regard to multiple variable logistic regression analysis, the only independent variables which were still significantly associated with possible poor attitude and practice of pesticide contamination include educational level, land tenure situation, formal training on pesticides and reading pesticides labels (Table 5). The results showed that illiterate respondents were 3.39 times more likely to have a poor attitude and practice about pesticide contamination than secondary and above-educated respondents (AOR =3.39, 95% CI:1.7, 6.77). This is based on the findings of a similar study on farmers in India which showed that an educational level associates pesticide misuse and disposal (Mohanty et al., 2013). The study conducted in Ethiopia by Negatu et al., (Negatu et al., 2016) revealed differences in poor practice between levels of education, which were consistent with our findings. This may be due to differences in reading levels, a condition of accounting’s increased attitude to accept technology. In line with this, Oyekale and Idjesa, (Oyekale & Idjesa, 2009) reported that the extremely low level of education affects the level of technology adoption and skills amongst farmers.
Similarly, respondents who could not read pesticide labels were 3.69 times more likely to have poor practice towards pesticide contamination than those who could read pesticide labels (AOR = 3.69, 95% CI: 1.62, 13.64). Formal training on the use of pesticides was a factor associated with poor practice and attitude towards pesticide contamination in the environment. Informants who have not been formally trained in pesticide use were 2.97 times more likely to have a pesticide contamination attitude and practice than those who take formal training (AOR = 2.97, 95% CI: 1.06, 8.37). Lack of adequate and appropriate knowledge of the side effects of pesticide residue misleads people: unsafe and indiscriminate use of pesticides in agriculture represents a major hazard to the environment and human health (Amera & Abate, 2008; Mohammed et al., 2018).
farmers are more knowledgeable about pesticide safety, have better ability to read, understand and follow hazard warnings on labels, and conceptualized the consequences of poor pesticide usage practices (Adesuyi et al., 2018; Akoto et al., 2016). Farmers who can read, in this study acknowledged that they were reluctant to read pesticide labels because of their experience with pesticide use (Jallow et al., 2017). This suggests that if farmers’ awareness is increased, the risk of pesticide contamination in the environment (water bodies) and public health may be minimized.

Overall, more than 80.16% of participants across the study area said they never received information about proper and safe disposal of pesticides. It is suggested that healthcare and local development agents should induce several adult education and training that could improve the knowledge, attitude and practice of farmers about the adverse effects and undesired consequences of poor pesticide use. They train on the proper use and safe disposal of pesticides and provide this information to smallholder farmers when they visit. It is also suggested that implementing strict surveillance and supervision on farms during spraying is important in reducing poor practice (Adesuyi et al., 2018). Finally, it is worth enacting a number of strong laws to prohibit the indiscriminate use of pesticides by farmers.

According to the results of our study, the land tenure situation is another important risk factor for poor pesticide use attitudes and practices among farmers. In respondents with land tenure, landholders were 1.8 times more likely to contaminate the environment than landowners (AOR =1.8, 95% CI: 1.52, 2.9). The study conducted by Mengistie et al. (B. T. Mengistie et al., 2017). In the central rift valley of Ethiopia, the size of land is shown to be another important factor positively associated with the amount and frequency of pesticides used.

5. Conclusion and recommendations
The assessment results showed that different pesticides such as insecticides, herbicides, fungicides and rodenticides are used indiscriminately by farmers around Lake Tana. These pesticides were improperly used, stored and disposed of in empty containers by farmers in the study area. This is due to a lack of awareness among farmers about the proper use of pesticides, (low educational level, lack of formal training in pesticide level, inability to read pesticides labels), lack of commitment about pesticide residue and its public health effects, and possibly due to lack of legal control over pesticide use. Thus, there is the possibility of finding these pesticides or their metabolite residues from fish and fish products, which brought them to market for public use. Laboratory investigations should therefore be conducted to confirm the presence of pesticides and/or chemicals in fish foods. The use of chemical pesticides with undesirable consequences should not be used and more use of bio-pesticides should be employed. Collaborative efforts should also be made to create awareness about the possible occurrence of pesticide residues for farmers, district agricultural development agents and health post officers. Consumer awareness should be raised among those concerned about the long-term harm caused by pesticides.

Authors’ contributions
BA, MA and MT developed the research concept. BA and MA contributed to the collection of materials and the drafting of the manuscript. MT provided valuable information on the subject of data analysis and the design of the study. MA and BA coordinated and supervised the study. BA and MA revised the manuscript. All authors agreed with the results and conclusions and approved the final manuscript.

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Competing Interests
The authors declare no competing interests.

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