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Environmental and Human Risk Assessment from Pesticides During Irrigation Practices: A Case of Haik, Amhara, Ethiopia

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Abstract

Agriculture is the backbone of the Ethiopian economy. Therefore, to increase productivity and to alleviate food insecurity, pesticides were used for in large-scale and small-scale irrigation farming system. On the other hand, pesticides have high risk on the environment and human beings, to estimate this type of pesticide risks the PRIMET model were used.

The four main steps were used in this study. The first step was to collect data from secondary sources and the literature. The second step was focused on consulting partners and local communities. The third step of the study mainly focused on identifying analytical and data collection tools. Lastly, risk identification and quantification were developed.

The application dose of 2,4-D and Malathion were higher than other pesticides, and its value were 1750 and 1400 g/ha. The predicted environmental concentration values of Lambdacyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides for Fish, Daphnia, and Algae were 0.15,0.25,0.53,0.89 and 0.12 respectively.

Propiconazole pesticides were 5000 g/ha and 68.6 mg/kg, which were higher than other pesticides in the terrestrial and Bee risk assessment type. The lambda-cyhalothrin was the higher risk, and ETR values pesticide for Fish, Daphnia, Algae, and Bees, and its ETR values were 70, 64, 6.99, and 5.50. The Profenofos pesticide ETR values were 59.63 and 49.12, which means high risk for terrestrial and Bee risk assessment. The ESTI% value of Lambdacyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides were 0.29, 0.01, 0.11, 0.03, and 0.00.

The higher the PEC value, the higher ETR, and ESTI%, which means the pesticide was a higher potential risk to the environment and human beings. The lambda-cyhalothrin and Malathion pesticides were at high possible risk in Lake Haik organisms (Fish, Daphnia, Algae) and Bee around the Lake. The Lambda-cyhalothrin pesticide was a higher potential risk pesticide for humans.

Keywords: Pesticides, Haik, PRIMET, ETR, PEC, ESTI, NEC, Risk assessment

Introduction

PRIMET Model

PRIMET is the acronym for Pesticides Risks in the tropics to Man, Environment, and Trade. Within the last few decades, the agriculture sector in tropical regions has been rising at a rapid pace. A large rise in the use of external inputs, like pesticides, has taken place in many different agricultural sub-sectors such as horticulture. This raised productivity has been beneficial for human health in terms of food security. Pesticide exposure, however, may affect the environment and human health through different emission routes. For example, via spray drift or runoff to surface water, accumulation in the topsoil, and leaching to groundwater.

PRIMET can estimate the risks of pesticide application to aquatic life (acute and chronic risk), non-target arthropods, Bees, terrestrial life (acute and chronic risk), Dietary exposure via the consumption of groundwater, vegetables, fish and macrophytes and. the use of groundwater as drinking water.

The risks are assessed at the household level, i.e., the actual pesticide application data were gathered from a farmer, pesticide characteristics and physical scenarios from the international website, and previous well-known papers were needed as input parameters. Based on the input parameters we can calculate the PEC and NEC value and then the risk assessment is expressed in Exposure Toxicity Ratios (ETR) which are calculated by dividing the exposure by the 'safe' concentration. The ETR is greater than 100, which means the concentration is greater than the safe concentration there is a Definite Risk, and the risk is higher. The second interpretation is when the ETR value is between 1 and 100 ($1 \leq ETR \leq 100$), there may be a risk (Possible Risk). The third option is if the ETR of less than 1, there is No risk.

PRIMET model has been used in South Africa, Cameroon, Ghana, and Ethiopia (Kenko & Ngameni, 2022). Pesticides applied to the field are of concern because of the risk of pollution, especially to vulnerable aquatic and terrestrial ecosystems (Onwona-Kwakye et al., 2020). The need to monitor the environmental risks of pesticides has been highlighted (Onwona-Kwakye et al., 2020).

Agriculture

Agriculture is often referred to as the backbone of the Ethiopian economy. Over 80% of the people living in rural areas are dependent on agriculture. Recent developments in the country brought about the intensification of farming activities, both in acreage and in the use of extrinsic inputs like pesticides and fertilizers (Teklu et al., 2015a).

Pesticides

Pesticides are part and parcel of the agricultural sector; in particular in the emerging intensive farming system of Ethiopia, to increase productivity and alleviate food insecurity, pesticides are applied in large-scale greenhouses and small-scale irrigation farms. The application of pesticides is not limited to agriculture only. Since the 1940s, Ethiopia has been utilizing pesticides for disease control and prevention programs. For the control of malaria, DDT and Malathion have been used ubiquitously. For this reason, Ethiopia is a signatory to important international conventions, such as the Stockholm convention (on persistent and Organic Pollutants signed in May 2001) and the Basel Convention (on the control of Transboundary Movement of Hazardous Wastes and their Disposal signed on March 1989), which are primarily designed for the control and/or eradication of hazardous pesticides. If not properly managed or controlled, pesticides can potentially create environmental and public.

Health risks (Negatu et al., 2016). These risks could be high, particularly for those occupationally exposed (Negatu et al., 2016). Occupational pesticide exposure can occur directly during mixing and pesticide application and indirectly while performing re-entry tasks in pesticide-treated crops or by take-home exposure.

The use of the pesticide, toxicity (which varies across and within different chemical classes), and physicochemical factors such as half-life (i.e., persistence in the environment). are the main factors for the risk of health effects (Shadung, 2014).

The Koc (the tendency of a chemical to bind to organic carbon) and half-life also influence the potential for pesticides to enter water resources via routes such as runoff (Shadung, 2014). Exposure to pesticides and their metabolites can occur via the route of environmental pollution. For instance, the consumption of agricultural produce that has pesticide residue or drinking from water sources that are contaminated with pesticides. Pesticides can be classified in many different ways: according to the target pest, the chemical structure of the compound used, or the degree or type of health hazard involved (Organization, 1990).Based on the types of pesticides, are insecticides, herbicides, fungicides, Avicides, Nematicides, Miticides, Rodenticides, household, public health and adjuvants, and growth regulators and these types of pesticides have their functional groups.

Pesticides are generally dispersed contaminants due to their toxicity, persistence, and degradation by-products. Chemical pesticides are categorized into four main types, namely organochlorines, pyrethroids, organophosphates, carbamates, and others. Bio-pesticides come naturally from living organisms, like plants, fungi, and bacteria. They are divided into three major groups; microbial, biochemical, and plant-incorporated protectants. On the other hand, pesticides are categorized into several types based on inorganic and organic pesticides and also based on ionic forms. Therefore, pesticides are classified into organic and inorganic (mineral derivatives), and organic pesticides are classified into synthetic (organophosphate, organochlorines, and carbamate plants and animals are synthetic and natural), microorganism based (fungal and bacterial). In another way, pesticides are classified as ionic (cat ion, basic, acidic, and miscellaneous) and non-ionic (chlorinated HCs, Dinitroanilides, and caranilates). When the world population increases, pesticide consumption also immediately increases to accelerate and maximize agricultural productivity and also to satisfy the demand for food. But, there are no clear long-term sustainability, soil degradation, water nitrification, natural resource management, and climate change effects (Lal et al., 2011).

The (Von Rumker, 1975) suggested that, from 100% of applied pesticides, 30 % are offtarget (drift and misapplication), whereas, 70% of the target area (45% on target crop, 15% off-target crop due to transport into the ground or non-target surface in the target area, and 10% is an off-target area due to volatilization, leaching and surface transport). From 45 % on target crop (41% off target insect due to residue on treated crop and 4% are on target insect). When we come to 4 % target insect (>3% is not contacted and <1% is absorbed by insect through contact, inhalation, and ingestion). (Gavrilescu, 2005) also suggested that from 100%quantity applied pesticides 45% on target crop, 30% off of the target area due to drift and misapplication, 15% off target surfaces due to entering into the ground, and 10% off target area due to volatilization, leaching, and surface transport.

The factors that affect the mobility of pesticides in the soil are PH, temperature, soil texture, sunlight, and organic matter and moisture. The pesticides that are transported in the soil are passed through the following pathway.

These move through the soil with water, are attached to soil particles , and are metabolized by microorganisms and /or free enzymes in the soil (Pavel & Gavrilescu, 2008). Considering the potential negative effects and creating an implementation mechanism for a signed convention, Ethiopia has promulgated several regulations for the safe management of pesticides or chemicals.

The use of agrochemicals for increased agricultural production in Ethiopia has increased over time. For example, annual pesticide imports increased from 1× 10^6 kg in 2000 to about 7× 10^6 kg in 2016 (Teklu et al., 2021). Pesticide effects on the environment and the biota can be assessed with the use of bioindicators, assessment of biomarkers, laboratory bioassays, and modeling. Many models have been used worldwide in EcoRA (Ecological Risk Assessment).

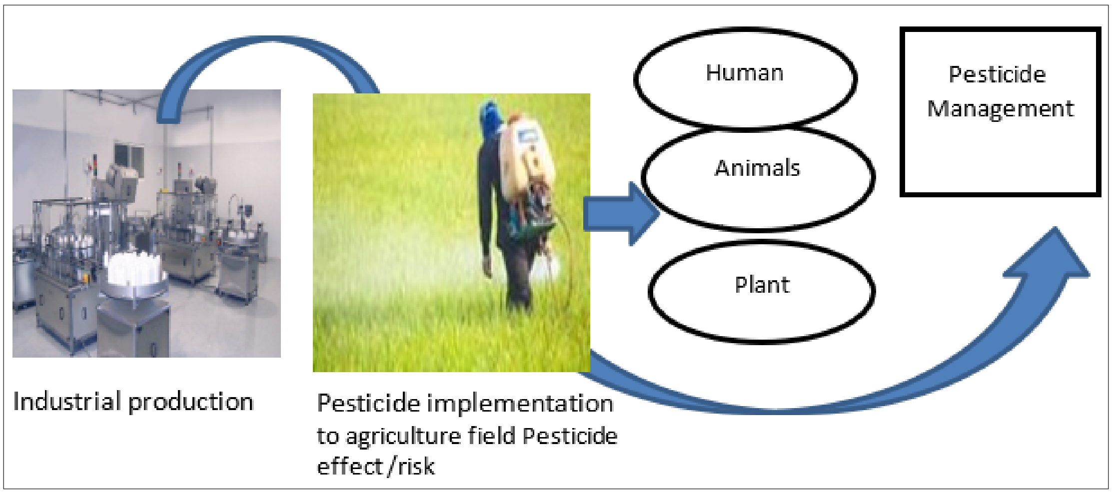

Figure 1: Pesticide production, use, risk and eco – friendly management

Materials and Methods

Description of the Study area

This study happened at the Haik irrigation system. The study area, Lake Hayq found in the south Wollo zone of the Amhara region in the eastern part of Ethiopia. It is 28 km and 430 km far from Dessie (the capital city of South Wollo) and Addis Ababa (the capital city of Ethiopia). It is a typical example of a highland Lake in Ethiopia with volcanic origin.

Lake Hayq is 6.7 km long and 6 km wide, with a surface area of 23 km^2. It has a maximum depth of 88 m and an elevation of 2,030 meters above sea level. It is one of two lakes in the Tehuledere woreda.The Haik town has a latitude and longitude of 11°18′N 39°41′E and an elevation of 2,030 meters (6,660 ft) above sea level.

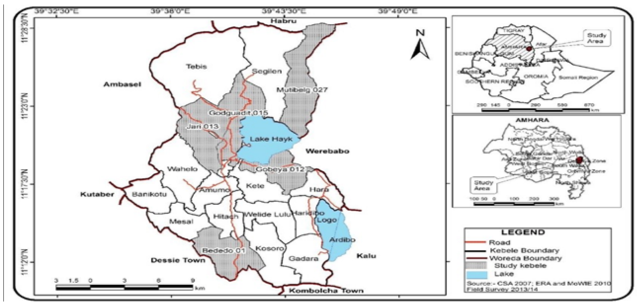

Figure 2: Map representation study area

Site Selection Criteria

The main reason to select this area for the study depended on the following criteria. These criteria were: first, the high use of pesticides in the study area. Second, it is a representative area for the study regarding agricultural advancement, crops grown, geography, and climate. The last criterion is the steady increase in crop farming in the area.

Pesticide Risk Assessment

In this pesticide risk assessment study, all the necessary information was used to a gathering, collect, analyze, and interpret data collected in two ways: fieldwork (primary data) and literature (Pesticide Database).

Study Design and Procedures

The following four main steps were used in this study, to plan, gather, and analyze data. The first step was to collect data from secondary sources and the literature. The second step was focused on consulting partners and local communities for better implementation with stakeholders and facilitating joint identification of criteria for selecting sample Woreda and commonly used pesticides and their selection and frequency of use. The third step of the study mainly focused on identifying analytical and data collection tools. The Pesticide Risks in the Tropics for Man, Environment, and Trade model, was used as an analytical tool for this study (Teklu et al., 2021).The input and ecotoxicological data sources applied to the model (Teklu et al., 2021).The survey tool and checklist were used to discuss with farm community leaders, private sectors, and supplies and service providers concerning the application and risks of agrochemicals were prepared. Lastly, risk identification and quantification were developed.

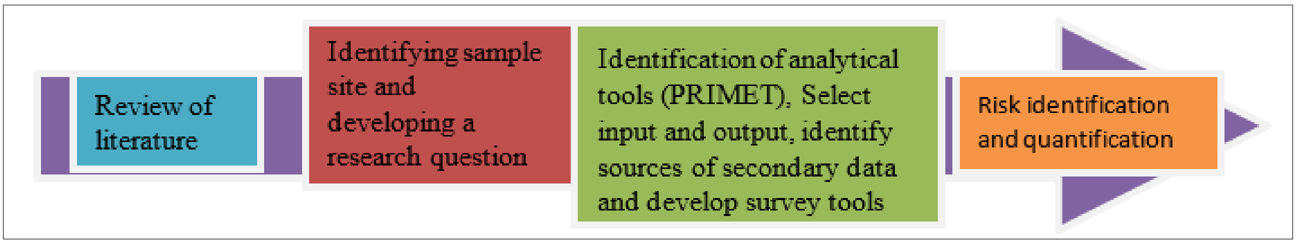

Figure 3: Study design illustrating the planning, data collection, and analyses

Input Data

The applied dose (g/ha), number of applications per crop season (frequency of use reported by farmers), the time between applications (application interval) (days), and Pesticide ecotoxicological data were entered one at a time into the Pesticide Risks in the Tropics for Man, Environment, and Trade model .The input parameter in the Pesticide Risks in the Tropics for Man, Environment, and Trade model in Ethiopia are pesticide characteristics, physical scenarios (water body), and pesticide application scheme.

Output Data

The Pesticide Risks in the Tropics for Man, Environment, and Trade model can calculate an exposure concentration (Predicted Environmental Concentration, PEC), threshold concentration for effects (Predicted no Effect Concentration, PNEC), and for each active ingredient. To calculate the Exposure Toxicity Ratio (ETR) value, divide the PEC value by the PNEC value. The ETR is greater than 1, which means the concentration is greater than the safe concentration, and the risk is higher. The second interpretation is when the ETR value is between 1 and 100 ($1 \leq ETR \leq 10$), there may be a risk. The third option is if the ETR of less than 1, there is no risk (Kenko & Ngameni, 2022).The pesticide Risks in the Tropics for Man, Environment, and Trade model estimates the risk of pesticides to aquatic organisms, terrestrial and bees taken into account (Fai et al., 2019).

The geometry and physicochemical parameters of the pesticides, the pesticide application scheme, and the pesticide characteristics were required for the input parameters of the Pesticide Risks in the Tropics for Man, Environment, and Trade model (Fai et al., 2019).

PRIMET Scenarios

During the pesticide Risks in the Tropics for Man, Environment, and Trade model scenario location of Ethiopia is divided into three. These locations represent worst-case scenario locations which means the risks associated with pesticide applications and crop production to surface water systems in Ethiopia. The first scenario location was called grid 1a, which represents elevations above 1500 m and a mean annual precipitation of 1326 mm. the second scenario was grid 2a which represents an elevation below 1500 m and a mean annual rainfall of 818 mm. The third scenario location (grid 2b) represents temporary lakes located in areas with an elevation greater than 1500 m and a mean annual rainfall of 1200. When estimating PEC and ETR values, the two scenario locations (i.e., 1 and 2b) elevations of surface waters (like Lakes), were considered in this study.

Data Collection

Survey on Pesticide and Use Patterns Information

Data collection methods and tools include focus group discussion (FGD), key informant interviews (KIIs), field observation, and literature reviews. These methods and tools listed above were used to cross-check and validate the information gathered and analyzed. The key informants were administrative bodies, agronomy and crop protection experts, and pesticide retailers. Each focus group had a size of five to eight individuals and participants of FGD that contain farmers active in pesticide spraying and working close to or adjacent to water bodies.

The key topics or issues discussed during FGD and KII include

1. The farmers' knowledge of pesticide registration and quality of products,
2. the types of pesticides used and method of application or spraying, and
3. the practice of using personal protective equipment (PPEs),
4. practices of protecting surface waters adjacent to their farm,
5. when and who is doing the spraying in the farm and the rate and frequency of application,
6. the interactions or relationships between the Spray Service Providers (SSPs) and Kebele Pesticide Agents (KPAs),
7. responsibilities of plant clinics and development agents regarding the control of the rate and frequency of application and
8. solid and liquid waste management of commercial farms in the studied Woredas.

During key informant interviews, FGD, and field observation, were conducted. The checklists contain types of water bodies in the selected Woredas, names if any, temporary or permanent, the presence of crops adjacent to water bodies and the type of dominant crop in the area, the size of land irrigated, and other purposes of the water bodies beside irrigation like the source of drinking, fishing, recreation. See detail information from appendix I.

A questionnaire survey was conducted from June to July 2014 in the irrigation system of Haik. The samples were randomly selected from 50 farmers that were actively involved in the field area. Questionnaires were administered in 2014 to obtain data on pesticide application schemes (the number of applications per crop season, the individual applied dosage/concentration (g/ha), and the time interval of applications (day) of the different pesticides).

The applied concentration (g a.i./ha) of each active ingredient, was calculated from pesticide manufacturer information. The default spray drift of 2.77 was used for analysis within the pesticide Risks in the Tropics for Man, Environment, and Trade model since the distance from the edge of farms to the ditches and streams was ≤ 1 m (Fai et al., 2019).

The predicted environmental concentrations (PEC) values were calculated using the pesticide Risks in the Tropics for Man, Environment, and Trade model tool. The NEC and ETR values were calculated from the pesticide Risks in the Tropics for Man, Environment, and Trade model and the formula or equation.

Physic-Chemical Properties of Pesticides

The pesticide characteristics required for the pesticide Risks in the Tropics for Man, Environment, and Trade model were solubility (mg/l), half-life in water (days), half-life in sediments (days), organic carbon-water partition coefficient (l/kg) molecular mass (g/mol), saturated vapor pressure (Pa), the coefficient for sorption on soil based on organic carbon content (Koc), and their Freundlich exponent (1/n) and Kom = 1.724 Koc, with Kom and Koc, expressed as L/kg and the Kom standing for the coefficient for sorption on soil (and sediment) based on organic matter content (Teklu et al., 2015a). Toxicity data for acute static tests such as median lethal dose (LC50s) of invertebrates (e.g., Daphnia), vertebrates (e.g., fish), and algae, as well as no observed effect concentrations (NOECs) for fish and Daphnia, established from laboratory studies, was obtained from literature and used within the model.

Some of the pesticide characteristics and the toxicity data were provided by the pesticide Risks in the Tropics for Man, Environment, and Trade model database, while the rest were obtained from various online databases, including the National Pesticides Information Center (NPIC) fact sheets, Pest Management Regulatory Agency Canada, National Center for Biotechnology Information PubChem Compound Database, PPDB (Pesticide Properties DataBase) (Fai et al., 2019), Ecotox Database (https://cfpub.epa.gov/ecotox/search.cfm), PAN Pesticide Database (2016), EXTOXNET (http://extoxnet.orst.edu/pips/ ghindex.html), and Pesticides Properties Database (HTTP:// sitem.herts.ac.uk/aeru/ppdb/en/atoz.htm).

Data Analysis

Human Risk Assessment

An acute reference dose was one of the parameters used for all the selected pesticides. If not available, the chronic toxicity value ADI was used instead of ARFD. The Estimated ShortTerm Intake (ESTI) was calculated by Eq. (1), using a body weight of 60 kg and assuming the large portion (LP) of intake of 6 L of drinking water per day. The value of 6L is triple the amount indicated by WHO (Teklu et al., 2015a). Because of high temperatures and possible high physical exertion. ESTI expresses the pesticide as a percentage of the total acceptable intake of one person in one day for acute toxicity.

ª8ªFªGª<%= ª?ªC-ªQªd * ªCª8ª6ªdªNªaªRª_ * 100 / ª4ªEª7ª9*ª5ªJ …………….. ª8ªD1

Where
ESTI = estimated short-term intake (%),
LP-dw = large portion of drinking water (L/day)
PEC water = momentary water concentration from applications (µg/L)
ARfD = acute reference dose
(µg/kg bwday BW = Body weight (kg)

Environmental Risk Assessment

The no-effect concentration values for aquatic organisms like Daphnia, algae, and fish were calculated from the acute ecotoxicity data (LC50 and EC50) values taken from the FOOTPRINT database (Teklu et al., 2015a). The no-effect concentration values were calculated for each species by multiplying its EC/LC50 by an extrapolation/assessment factor.

ªAª8ª6ªSª\ª_ª9ªVªh=0.01*ª?ª650 ª9ªVªh ……………ª8ªD 2

ªAª8ª6ªSª\ª_ª7ªNª]hª[ªVªN=0.01*ª8ª650 ª7ªNª]hª[ªVªN……….. ª8ªD3

ªAª8ª6ªSª\ª_ª4ªYªTªNªR=0.1*ª8ª650 ª4ªYªTªNªR ……….. ª8ªD4

Where:
NEC water= No effect concentration for the water compartment (mg/L)
LC50 = concentration that kills 50% of the test organism (mg/L)
EC50 = concentration that affects 50% of the test organism (mg/L)
0.01 And 0.1 = assessment factor

A risk assessment was performed by comparing PEC values to NEC values for each of the organisms.

ª8ªGªE= ªCª8ª6 / ªAª8ª6 … ……………ª8ªD5

Where:
ETR water -org = Exposure Toxicity Ratio due to applications (-) PEC water = momentary water concentration from applications (mg/L)
NECorg = No Effect Concentration for the water organisms' fish, daphnia, or algae (mg/L).

Data Statistical Analysis

The pesticide application scheme, water physicochemical characteristics, and physical scenario data were entered into Microsoft Excel. The applied dose (g/ha), number of applications per crop season (frequency of use reported by farmers), the time between applications (application interval) (days), and Pesticide ecotoxicological data were entered one at a time into the pesticide Risks in the Tropics for Man, Environment, and Trade model. The pesticide Risks in the Tropics for Man, Environment, and Trade model was used to calculate an exposure concentration of Predicted Environmental Concentration (PEC) and a threshold concentration effect

(Predicted no Effect Concentration (PNEC). The Exposure Toxicity Ratio (ETR) was calculated by dividing the PEC by the PNEC. And also, to calculate the ESTI value for human risk. The ETR is greater than 1, which means the concentration is greater than the safe concentration, and the risk is higher. The second interpretation is when the ETR value is between 1 and 100 ($1 \leq ETR \leq 10$), there may be a risk. The third option is if the ETR of less than 1, there is no risk.

Result and Discussion

The three input parameters were required in the PRIMET model. These parameters were pesticide characteristics, physical scenarios, and application schemes listed in tables 2, 3 in appendix 1 and table 1 respectively below.

The pesticide characteristics data in table 2 mean the data that were descriptions of the pesticide collected from National Pesticides Information Center (NPIC) fact sheets, Pest Management Regulatory Agency Canada, National Center for Biotechnology Information.
PubChem Compound Database, Ecotox Database (https://cfpub.epa.gov/ecotox/search.cfm), PAN Pesticide Database (2016), EXTOXNET (http://extoxnet.orst.edu/pips/ghindex.html), and Pesticides Properties Database(HTTP://sitem.herts.ac.uk/aeru/ppdb/en/atoz.htm) based on (Teklu et al., 2015a) procedures refer from appendix 1 below .

Physical scenarios data of the pesticides in table 3 in the appendix 1 were the data that express the physical characteristics information of the Lake Haik assessment input data of the study area generated from the scientifical evidence (Eddleston et al., 2009; Fetahi et al., 2011; Status et al., 2022; Washington, 1969; Yesuf et al., 2013).

The pesticide data of application schemes were collected in the table 1 from farmers and pesticide experts from the study area by preparing a survey questionnaire. The survey questionnaire consists of the pesticide type applied in the study area, types of crops, application interval, the applied dose, frequency of application, application season, and methods of application identified in the study area. Based on the investigation, the five active ingredients or pesticides applied which means that the pesticide of lambdacyhalothrin, malathion, 2,4-D, propiconazole, and profenofos for maize, cabbage, wheat, and teff, wheat, and onion crop type orderly. The application methods and season of all five pesticide ingredients were the same.

The application dose of 2,4-D was 1750g/ha and higher than other pesticides. The application dose of the pesticide of lambda-cyhalothrin and propiconazole was 500g/ha and had equal dose values. The application dose of Profenofos was 700 g/ha. Based on this, the Profenofos pesticide was the second higher usage of applied dose next to a 2,4-D pesticide. All the investigated pesticides dose values were less than (Teklu et al., 2016). research investigations. All the pesticide application dose value were higher except lambdacyhalothrin pesticide when compared to (Brice et al., 2022). investigation.

Application scheme					
	Active ingredients				
input parameters	Lambda-cyhalothrin	Malathion	2,4-D	Propiconazole	Profenofos
Pesticide type	Insecticide	Insecticide	Herbicide	Fungicide	Insecticide
Chemical group	Pyrethroid	Organophosphate	Phenoxy	Triazole	Organophosphate
Crops type	Maize	Cabbage	Wheat,Teffe	Wheat	Onion
Application Interval (Dt) (days)	21	30	30	30	15
Applied Dose/ (M)stacked (g/ha)	500	1400	1750	500	700
Frequency of application (n)	2	3	2	2	3
individual dose (m)=M/n (g/Ha)	250	466.67	875	250	233.33
%Drift /drift ditch	2.77	2.77	2.77	2.77	2.77
Method of application	Spray	Spray	Spray	Spray	Spray
Application season	Summer & Winter	Summer & Winter	Summer & Winter	Summer & Winter	Summer & Winter

Whereas: Summer months = June, July and August
Winter months = December, January, and February in Ethiopia calendar

Table 1: Application scheme of pesticides in the study area. All the data are taken from Field Survey interview data

The predicted environmental concentration (PEC) of pesticide results used in the study area

The PEC value of the Propiconazole pesticide was 0.89 µg/L and 3.06 mg/kg, which were higher than other pesticides from aquatic (Fish, Daphnia, and Algae) and terrestrial risk assessment types orderly. The PEC value of 2,4-D and Propiconazole for Bee was 875 g/ha, and the value was higher when compared to other Bee PEC values. The PEC value of Lambda-cyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides for Fish, Daphnia, and Algae were 0.15,0.25,0.53,0.89 and 0.12 respectively , and when the Lambdacyhalothrin, Malathion pesticides were higher and the Propiconazole, and Profenofos pesticides were lower as compared to (Teklu et al., 2016). research investigation . All the value of Malathion, 2,4-D and Propiconazole pesticides were higher values except Lambda-cyhalothrin pesticide when compared to (Brice et al., 2022). Research investigation.

All the Fish , Daphnia and Algae PEC values were lower than (Onwona-Kwakye et al., 2020b) investigation for Lambda-cyhalothrin.The PEC value of Lambda-cyhalothrin pesticide was higher and 2,4-D pesticide was lower than (Fai et al., 2019) investigation.

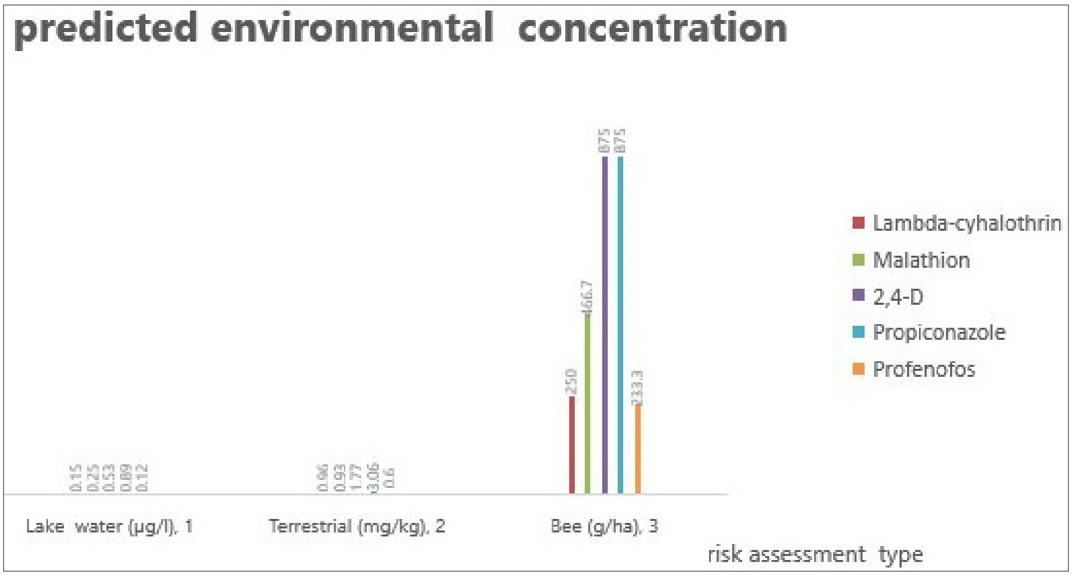

Figure 4: Graphical representation of PEC result value

The no effect concentration (NEC) of pesticide results used in the study area

The NEC(PNEC) values of 2,4-D pesticide were 1000, 1342, and 10000 µg/L. It was a higher value for Fish, Daphnia, and Algae when compared to other similar risk assessment-type pesticides. The value of Lambda-cyhalothrin pesticide were 0.00, 0.00, and 0.02, which have very small NEC(PNEC) values for Fish, Daphnia, and Algae risk assessment types as compared to other pesticides.

The 2,4-D and Propiconazole pesticides were 4700 and 5000 g/ha. These were higher than other pesticides in the Bee risk assessments orderly. The Lambda-cyhalothrin and Propiconazole pesticide NEC(PNEC) values were 50 and 68.60 mg/kg, which was a higher value than other pesticides in the terrestrial risk assessment. The Profenofos pesticide NEC(PNEC)value was 0.01. All the NEC value for Fish and Daphnia were equal but all the Algae values were higher except propiconazole pesticide when compared to (Teklu et al., 2016) investigation . The NEC value for Lambda-cyhalothrin and Malathion pesticides were higher ,whereas the 2,4-D was lower values than (Brice et al., n.d.) and equal value for Propiconazole pesticide . All the Fish , Daphnia and Algae NEC values were lower than (Onwona-Kwakye et al., 2020) investigation for Lambda-cyhalothrin. The NECvalues for Lambda-cyhalothrin and 2,4-D pesticide were equal when compared with (Fai et al., 2019) investigation.

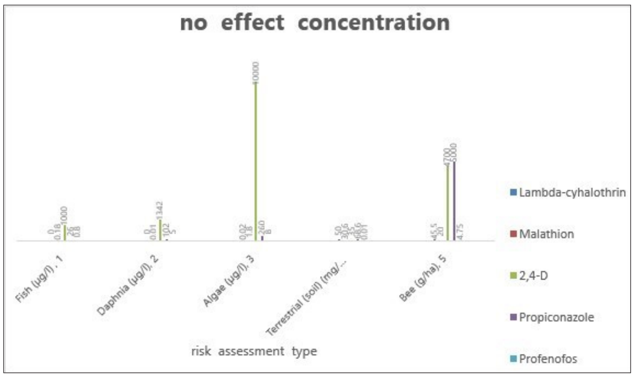

Figure 5: Graphical representation of the NEC result value

The exposure toxicity ratio (ETR) of pesticide results used in the study area

In this part when the ETR is greater than 100, which means the concentration is greater than the safe concentration there is a Definite Risk, and the risk is higher. The second interpretation is when the ETR value is between 1 and 100 ($1 \leq ETR \leq 100$), there may be a risk (Possible Risk). The third option is if the ETR of less than 1, there is No risk.

The ETR value for lambda-cyhalothrin pesticides was 70, 64, and 6.99 for the Fish, Daphnia, and Algae risk assessment types. The lambda-cyhalothrin pesticide was very high value and risky. The value of 2,4-D pesticide was 0.00 and low values and risk in the Fish, Daphnia, and Algae risk assessment type. The ETR values of profenofos pesticides were 59.63 and 49.12, and the pesticide has high possible risks (orange) in terrestrial and Bee risk assessment. The ETR values of lambda-cyhalothrin pesticide were 0.02 and 0.18 and very low compared to other pesticides in terrestrial and Bee risk assessment.

In general, in lambda-cyhalothrin pesticide, the ETR values were 70, 64, 6.99 for Fish, Daphnia, and Algae, and 5.50 for Bees. These values lied between 1 and 100, which means it has a higher possible risk of Fish, Daphnia Algae, and Bees. In Malathion pesticide, the ETR value for Fish, Daphnia, and Bees were 1.36 ,35.04 and 23.33, which means it has a high possible risk for Fish, Daphnia, and Bee. The ETR values of profenofos pesticide were 59.63 and 49.12 for terrestrial and Bee risk assessment. It has a high possible risk for terrestrial and Bees. All the other values were below 1, which means it has no risk on Fish, Daphnia, Algae, terrestrial, and Bee risk assessment.

The ETR value for Lambda-cyhalothrin and Malathion pesticide were higher , whereas, for Propiconazole and Profenofos pesticides were lower value than (Teklu et al., 2016) investigation for Aquatic ecosystem like Fish, Daphnia and Algae .The ETR value for Lambda-cyhalothrin and Malathion pesticide were lower whereas , for 2,4-D and Propiconazole pesticides were higher than (Brice et al., n.d.) for Bees investigation. The ETR values of Lambda-cyhalothrin pesticide was lower and 2,4- D pesticide was already equal value when compared to (Onwona-Kwakye et al., 2020) investigation for aquatic ecosystem like Fish, Daphnia and Algae.

The ETR values of Lambda-cyhalothrin and 2,4-D were higher than (Onwona-Kwakye et al., 2020) research for Terrestrial (soil) ecosystem , but lower value for Lambdacyhalothrin and higher value for 2,4-D pesticide for Bee investigation . All the ETR value of lambda-cyhalothrin and 2, 4-D pesticides were higher than (Fai et al., 2019) investigation for Daphnia and Fish aquatic ecosystem.

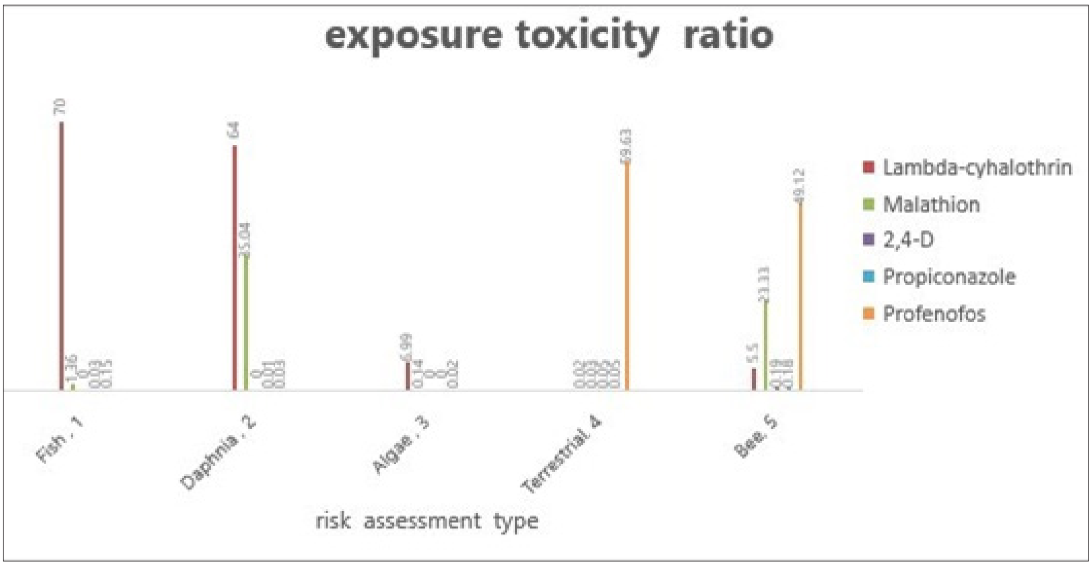

Figure 6: Graphical representation of the ETR result value

The ESTI% value for Human risk assessment

Based on the world health organization's indication, an adult person's body weight is 60kg, the daily water drinking is 6L/d, and the acute reference dose is taken from the Pesticide. The ARDF value for Lambda-cyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides were 5, 300,50,300, and 1000(µg/kg BW from the literature.

The PEC value of the Haik Lake for Lambda-cyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides were 0.15,0.25, 0.53,0.89 and 0.12 from the model and calculation.

Based on this calculation, the ESTI% value of Lambda-cyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos pesticides were 0.29, 0.00, 0.11, 0.03, and 0.00 respectively.

From this analysis, the ESTI% value of the Lambda-cyhalothrin pesticide was 0.29. It was a high risk to humans as compared to other pesticides. The ESTI% value of the Profenofos was 0.00. It was a low value and risk to humans compared to other pesticides. The ESTI% value for Malathion pesticide was higher and for 2,4-D pesticide was lower than (Teklu et al., 2015). except Lake Tana investigation for 2,4-D pesticide.

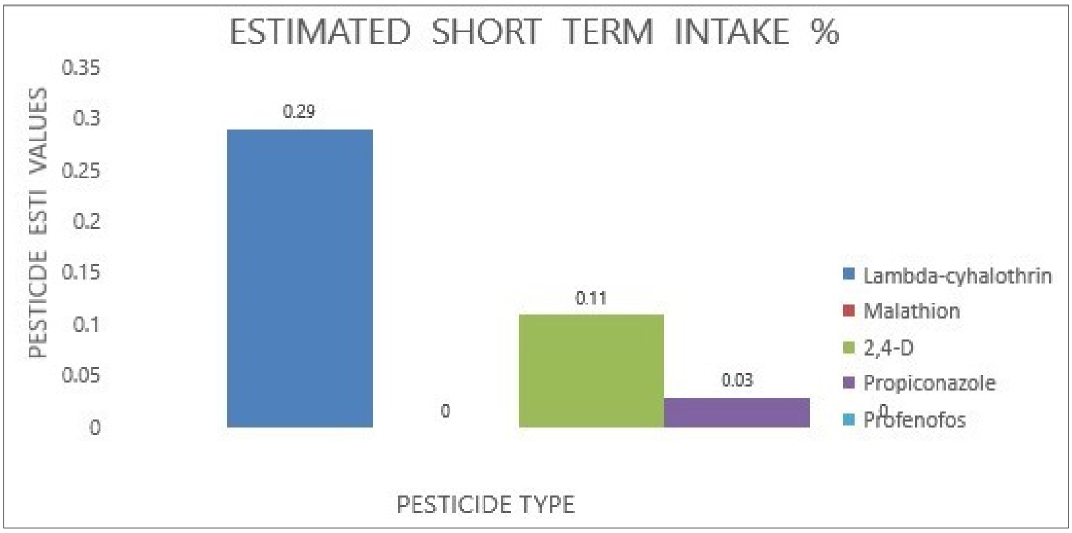

Figure 7: Graphical representation of ESTI% result value

Conclusion

All the input parameters were collected and gathered from primary and secondary data. During this observation, the five main types of pesticides were applied and identified in the study area around Lake Haik. The names of these pesticides were Lambda-cyhalothrin, Malathion, 2,4-D, Propiconazole, and Profenofos. The application methods and season of all five-pesticide ingredients were the same. The 2,4-D pesticide has a higher application dose but has not been at any risk. The lambda-cyhalothrin, malathion, and profenofos pesticide have been possibly risky for Fish, Daphnia, Algae, terrestrial, and Bee risk assessment.

The higher the PEC values and the lower the NEC value, the higher the ETR value and the higher risk on the Lake Haik, terrestrial, and Bee risk assessment. During this study, the Propiconazole pesticide was a high PEC on Lake Haik organisms, on the terrestrial and Bees around Lake Haik. The 2,4-D pesticide was a high NEC on Lake Haik. The Propiconazole pesticide was a high NEC on the terrestrial and Bees around Lake Haik.

The lambda-cyhalothrin pesticide was very low NEC in Lake Haik. The profenofos pesticide was very low PEC on Lake Haik.

For the lambda-cyhalothrin and Malathion pesticides, the ETR value is more than one and less than 100, which means it has a high possible risk in Lake Haik and Bee around the Lake. For the Profenofos pesticide, the ETR value is more than one and less than 100, which means it has the highest possible risk in terrestrial and Bees around Lake Haik, but it may have been a risk on Lake Haik. All the other values were below 1, which means have been no risk on Fish, Daphnia, Algae, terrestrial, and Bee risk assessment.

The higher value of the PEC, the lower the ARfD value, and the higher ESTI%.The higher the ARfD, the lower the PEC value, and the lower the ESTI% value. Generally, the PEC value was directly proportional to ESTI% and ETR values. The higher the PEC value, the higher ESTI% and ETR values, and the reverse is true. From this analysis, the ESTI% value of the Lambda-cyhalothrin pesticide has a high value and risk on humans. The Profenofos pesticide was low value and risk on humans compared to other pesticides.

Recommendation

As a recommendation, when applying pesticides in terms of risk to humans and the environment based on research investigation. From this research paper, the 2,4-D pesticide has a low risk compared to Lambda-cyhalothrin and other pesticides regarding humans and the environment around lake Haik. Pesticides have a risk to aquatic organisms like Fish, Algae, Daphnia, terrestrial (soil), and bees in and around Lake Haik. From the public health and environmental point of view, registering pesticides alone cannot safeguard public health. Therefore, periodic surveillance and research-based pesticide distribution in the environment and the human body is necessary to identify the level of risk and mitigation measures. As engineering solution, before apply pesticides identifying the sources, way of entering into the environment and human being and give engineering solution were necessary based on research.

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Appendix

Pesticide characteristics					
Parameters (for input)	pesticide types				
	Lambdacyhalothrin	Malathio	2,4-D	Propiconazol e	Profenofo s
DT50 system (d)	15.10	0.40	18.2	561	0.1
EC50 Algae(mg/l) from model	0.00021	0.018	100	2.6	0.08
KOC(L/kg)	283.707	1.8	0.0393	1.086	2.016
KOM = 1.724 Koc(L/kg)	489.111	3.1032	0.06775	1.8723	3.475584
L/E/C 50 Daphnia (mg/l)	0.00023	0.0007	134.2	10.2	0.5
L/E/C50 Fish (mg/l)	0.00021	0.018	100	2.6	0.08
mpesticide(g/mol)	449.85	330.36	221.04	342.22	373.63
NOECDaphnia(mg/l)	0.0000022	0.00006	46.2	0.31	0.5
NOEC fish (mg/l)	0.000031	0.091	27.2	0.068	0.002
SOL(Tref)(mg/l)	0.005	148	24300	150	28
Tref SOL(K)	293.15	293.15	293.15	293.15	293.15
Tref kw(K)	293.15	293.15	293.15	293.15	293.15
Tref VP(K)	293.15	293.15	293.15	293.15	293.15
VP (Tref)(Pa)	0.0000002	0.0031	0.000009	0.000056	0.00253
LD50 (ug/bee)	0.91	0.4	94	100	0.095
ADI (mg/kg*d)	0.0025	0.03	0.05	0.04	0.03
DT50 soil(d)	175	0.17	4.4	71.8	7
Efmammals (-)	100	100	100	100	100
NOAELmammal(mg/kg*d)	0.7	34.4	40.2	43.7	0.3
Log (Kow)/(logP) (L/kg)	5.5	2.75	-0.82	3.72	1.7
LC50 earth worms(mg/kg)	500	306	350	686	0.1
NOEC earth worms(mg/kg)	3.125	0.1	62.5	6.47	0.1

Table 2: pesticide characteristics data

Physical scenarios (water body information)	
Parameters	Amount in unit
b(m)bottom width	6m
EF water acute algae	0.10
EF water acute Daphnia	0.01
EF water acute Fish	0.01
EF water chronic Daphnia	0.10
EF water chronic fish	0.10
Height water body (h(m))	10m
Length of water body (L(m))	6700m
Mass fraction of organic matter (mom(g/g))	0.30g/g
Side slope horiz /vert (S1 (-)	5.33
Mass conc. Susp. solid in water (SS (kg/L))	0.4648kg/L
Ambient temp.(T(K))	300.45 K
Flow velocity (v(m/d))	0.0775463m/s
Depth of field /plant(m)	0.05m
Ef soil acute (-)	0.10
EF soil chronic (-)	0.20
Dry bulk density soil (kg/dm^3 soil)	1kg/dm^3
Efbee	50
Body weight (bw(kg))	60kg
Daily fish consumption (cons fish(kg/d))	0.03234 kg/d
Daily macrophyte consumption (cons MF (kg/d))	4.50 kg/d
Daily drinking water consumption (cons water(L/d)	2L/d
Daily vegetable consumption (cons Veg(kg/d))	0.20 kg/d
Pecveg item (mg pesticde/kg veg)	0.02mg/kg

Table 3: physical scenarios data