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Pesticide Use by Vegetable Growers in Rupandehi District, Western Nepal: Environmental and Health Risk Effects

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Abstract

Rupandehi district, located in the southern part of western Nepal, is well-known for producing different kinds of vegetables and has many commercial vegetable-growing pocket areas. This study aims to identify the types of pesticides used and their effect on human health and environment. The data were collected using semi-structured interviews with 150 vegetable growers, 40 pesticide retailers, and focus group discussions with key informants. This study found that the vegetable growers used insecticides with 25 technical names; fungicides with 10 technical names; and herbicides with 4 technical names. The maximum vegetable growers (40%) experienced respiratory tract irritation, followed by skin disorders (20%), asthma (13%), gastrointestinal disorders (12%), eye irritation (10%), and neurological effects (9%) in the study area. Similarly, air, water, and land pollution were found in the study area mainly due to the improper pesticide use and disposal of pesticide containers. Most of the vegetable growers (47%) illegally disposed of pesticide containers, followed by burning in the field (28%), storing foodstuffs (10%), putting oil (7%), selling to recyclers (5%), and burying in the field (3%). This study may provide baseline information for pesticide management and utilization in this area, and there is an urgent need for a thorough investigation into the harmful effects of pesticides on farmer health and pesticide residues in vegetables.

Keywords: Active ingredient, Pesticide, respiratory tract, semi-structured interview, WHO class

Introduction

Pesticides are toxic medicines utilized to kill or eradicate hazardous pests found in seeds, plants, trees, animals, and birds (Pesticide Act, 1991). These are chemical substances that are utilized to eliminate pests such as insects, rodents, fungi, and undesired plants (weeds). It includes insecticides, fungicides, weedicides, rodenticides, nematicides, acaricides, molluscicides, and bactericides. Pesticides can be classified chemically as organochlorines, organophosphates, carbamates, synthetic pyrethroids, and biorationals or biopesticides. Approximately 800 pesticides are registered for usage throughout the United States, a few of them are utilized in huge amounts and may cause a range of health issues (Schwingl et al., 2021). However, 3,827 pesticides are registered so far in Nepal under their trade names, with 163 under their common/technical names (PQPMC, 2020). World Health Organization (2009) categorized pesticides into six groups based on their hazard level, such as extremely hazardous (Ia), highly hazardous (Ib), moderately hazardous (II), slightly hazardous (III), non-hazardous (NH) or unlikely to present acute hazard in normal use (U), and hazard level not calculated (NC).

Pesticides are used in vegetable crops to protect them from unwanted pests that could lead to crop loss. Therefore, pesticides provide primary benefits by killing pests that feed on crops, resulting in increased agricultural output. According to Webster et al. (1999), pesticide use leads to a substantial enhancement in crop yield, whereas economic losses would be significantly higher without it. However, irrational use of chemical pesticides in vegetable crops threatens both the environment and human health. The hazards of pesticide use have outweighed the benefits (Mahmood et al., 2016). Pesticides can reach water bodies through drift, runoff, soil leaching, or direct application, potentially affecting aquatic life. Herbicides may kill aquatic vegetation, resulting in low oxygen levels and lower productivity of fish (Helfrich et al., 2009). Scholz et al. (2012) found that excessive pesticide use led to a drop in fish populations among many species. Pesticides pose a significant risk to humans, particularly babies and kids, due to their non-specific nature and heavy application. Pesticides may get into the body by eating, breathing, or skin penetration (Spear, 1991). However, the majority of individuals are affected by pesticides found in their food and bioaccumulation/bio-amplification of pesticides. Moreover, the burning of pesticide containers in the field and illegal dumping also cause air and land pollution.

Nepal is an agricultural country, with the majority of the population (50.1%) employed in agriculture, forestry, and fisheries (NSO, 2021). They farm a variety of food crops, vegetables, and fruits as their main source of income. According to the Agriculture Census 2021/22, around 47.9% of Nepalese farmers grow vegetables. In Nepal, the average national use of pesticides is 396 g a.i./ha, with vegetables accounting for the majority of usage (Ghimire and GC, 2018), and 26.7% of vegetable growers use pesticides (NSO, 2023). Of these, 53.02% use mildly hazardous pesticides, 33.2% use moderately toxic pesticides, 12.9% use highly toxic pesticides, and only 0.7% use extremely toxic pesticides. Similarly, Rupandehi district is located in the southern part of western Nepal, and the majority of the population engages in agriculture, cultivating food crops and vegetables using various types of pesticides. Fifteen pocket areas were chosen for commercial vegetable production in this district: Dhakdhakai (Rohini Rural Municipality), Parroha (Sainamaina Municipality), Gajedi (Kanchan Rural Municipality), Khudabagar (Lumbini Sanskritic Municipality), Dhamauli (Mayadevi Rural Municipality), Suryapura (Devdaha Municipality), Harnaiya (Siyari Rural Municipality), Kamhariya (Mayadevi Rural Municipality), Rayapur (Marchwari Rural Municipality), Jogada (Gaidahawa Rural Municipality), Majhagawan (kotahimai Rural Municipality), West Amuwa (Siyari Rural Municipality), Siktahan (Devdaha Municipality), Siddharthanagar Municipality, and Devdaha Municipality (DADO, 2072). However, vegetable growers and locals use pesticides irrationally in vegetable crops, posing severe environmental and health risks in this area. They are unaware of the adverse effects of chemical pesticides on the environment and human health. Moreover, there are some government institutions in this district to govern pesticide use and misuse, sale, distribution, regulation, and management, however, their effort seems ineffective due to various reasons that have resulted in pesticide pollution, environmental degradation (soil, water, and air), and human health deterioration. There are a few research in this area that look at pesticides used by vegetable growers and their effects on the natural environment and human health. Therefore, this study aims to identify the various types of pesticides used in vegetable crops and their effect on the environment and human (especially vegetable growers) health in the study area.

Materials and Method

Selection of study area

The present study was carried out in Tilottama Municipality, Devdaha Municipality, Siyari Rural Municipality, and Gaidahawa Rural Municipality in Rupandehi District (Fig. 1). All wards in the selected municipalities and rural municipalities were not chosen as research areas because cultivating vegetables is commercially practiced in only a few wards. Both rural municipalities and municipalities were chosen as research areas to find out about pesticide usage by vegetable growers and locals in both urban and rural areas and its impact on socio-economic conditions and health issues. Similarly, both the vegetable growing pocket area (Devdaha Municipality and Gaidahawa Rural Municipality) and the non-pocket area (Siyari Rural Municipality and Tilottama Municipality) of this district were chosen as study sites (DADO, 2072).

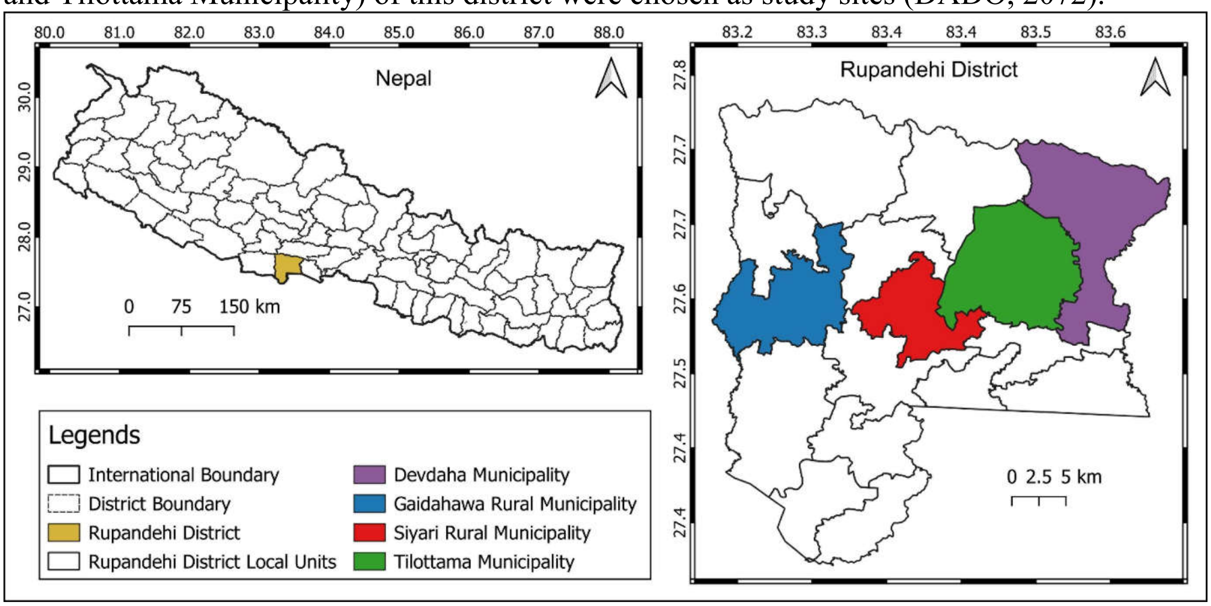

Fig. 1 Location map of the study area

The study area, Rupandehi district (latitudes: 27^{0}20'00" N to 28^{0}47'25" N, longitudes: 83^{0}12'16" E to 83^{0}38'16" E), is located in Lumbini province, Western Nepal. It shares borders with India in the south, as well as Palpa, Nawalparasi, and Kapilvastu in the north, east, and west respectively. The altitude ranges from 100 to 1229 meters above sea level (DDC, 2071).

The district has been divided into ten rural municipalities, five municipalities, and one sub-metropolitan city. In terms of geography, it is separated into three regions: Chure (14.5%), Bhabar (0.6%), and Terai (84.9%).

Sample size and sampling technique

For this investigation, a purposive sampling strategy was used to select the sample and sample size. Sampling was conducted in such a way that both the commercial vegetable-producing pocket area and the non-pocket area were included as samples. Two municipalities and two rural municipalities were deliberately selected as samples from the five municipalities, ten rural municipalities, and one sub-metropolitan city of Rupandehi district. Ten locals, including vegetable-growing farmers, were chosen for interviews from each of the five wards of Devdaha Municipality and Gaidahawa Rural Municipality, as well as ten vegetable-growing farmers from two wards of Tilottama Municipality and three wards of Siyari Rural Municipality. A total of 150 participants were chosen for interviews. Similarly, 10 pesticide retailers/resellers from each rural municipality and municipality (for a total of 40) were chosen for formal interviews. Furthermore, a focus group discussion with ten key informants from each rural municipality and municipality was held to collect information.

Data collection

A standard questionnaire was developed to collect primary data on the types of pesticide use, as well as its impact on the environment and health risks of vegetable growers. Then, semi-structured interviews were conducted with vegetable growers, locals, pesticide retailers, and other elderly people to collect information about the types of pesticides used in vegetable crops, the various disorders and diseases associated with pesticide use in vegetable growers, and the effect of pesticides on the environment. Farmers who raise vegetables participated in focus group discussions (FGDs) and key informant interviews. Data were also collected using the Participatory Rural Appraisal (PRA) approach. The present study includes three field visits in 2020, each lasting one week.

Data Analysis

The data collected from field surveys, observations, semi-structured interviews, key informant interviews, and focus group discussions were analyzed in percentages, tables, and bar diagrams using Microsoft Excel 10 to draw a consolidated conclusion about pesticide use and misuse, as well as their impact on the environment and human health.

Results and Discussion

Types of pesticide used in vegetable crops

This study found that vegetable growers and local people in Tilottama Municipality, Devdaha Municipality, Siyari Rural Municipality, and Gaidahawa Rural Municipality utilized three types of pesticides in vegetable crops to manage specific pests, diseases, and weeds that directly affect crop health and yield: insecticides, fungicides, and herbicides. They utilized insecticides with 45 different trade names and 25 common/technical names; fungicides with 15 different trade names and 10 common/technical names; and herbicides with 10 different trade names and 4 common/technical names (Tables 1, 2, & 3). They were not using acaricides, molluscicides, bactericides, nematicides, and rodenticides in their vegetable crops. It may be due to the severe threats of insects, fungi, and weeds in their vegetable crops than bacteria, nematodes, molluscs, rodents, or mites and ticks. Similarly, mites and ticks are generally less common and less damaging than insects, and insecticides are frequently used to control mite populations; the effect of snails and slugs is usually more localized and less severe than insects or fungi; rats and mice pose a greater threat in stored crops than in the field; and bacterial diseases are less common than fungal diseases.

Table 1: Insecticides used in vegetable crops in the study area, including trade names, technical names, active ingredients, formulation, and WHO class

S. N.	Trade name	Common name/ Technical name	A.I. %	Formu-lation	WHO Class
1.	Ekka/Super Ekka/Action	Acetamiprid	20%	SP	II
2.	Derrick	Alphacypermethrin 1% + Chlorpyrofos 16%	17%	EC	II
3.	Ulfa/Vijoy/Surya Alpha Plus/Alpha Plus/Farsa/Cobra	Alphamethrin	10%	EC	II
4.	Celphos	Aluminium phosphide	56%	TAB	NC
5.	Highlight	Bifenthrin	10%	EC	II
6.	Paradon	Carbofuran	3%	GR	Ib
7.	Caldon-50	Cartap HCl	50%	SC	II
8.	All Fighter/ Bang-505/	Chlorpyrifos 50% + Cypermethrin 5%	55%	EC	II
9.	Bullet	Chlorpyrifos 20% + Cypermethrin 5%	55%	EC	II
10.	Cyper 10/Super Fighter/Suryamethrin/ Cyper Hit 10	Cypermethrin	10%	EC	II
11.	Delta	Deltamethrin 1% +Triazophos 35%	36%	EC	II
12.	Bloom/Revan/ Starchlor	Dichlorvos	76%	EC	Ib
13.	Rogorin/Anugor/Rogor Plus	Dimethoate	30%	EC	II
14.	Kingstar	Emamectin benzoate	5%	SG	II
15.	All Fensuper	Fenvalerate	20%	EC	II
16.	Kimida/ Victor/A-One	Imidacloprid	17.8%	SL/EC	II
17.	Katyavani Imida	Imidacloprid	30.5%	SC	II
18.	Katar	Lambda cyhalothrin	5%	EC	II
19.	Cigna-5ec	Lufenuron	5.4%	EC	III
20.	Ki-Thion	Malathion	50%	EC	III
21.	Current/Profesar	Profenophos	50%	EC	II
22.	Nzgin	Quinalphos	25%	EC	II
23.	Tarzan	Triazophus	40%	EC	II
24.	Wiltox	Hexythiazox	5.45%	EC	NH
25.	Lethal TC	Chlorpyrifos	20%	EC	II
26.	Doom	D-Phenothrin + Prallethrin + Imiprothrin	-	EC	II
27.	Delfin	Chlorpyrifos 50% + Cypermethrin 5%	55%	EC	II

Vegetable growers purchase pesticides from a pesticide retailer/seller by providing a storyline about the detrimental activity of various pests on their vegetable crops, and the pesticide retailer then provides pesticides according to his judgment. According to this study, vegetable growers continued to use insecticides (Dichlorvos and Carbofuran) and fungicides (Aluminium phosphide) that the Government of Nepal had banned. Dichlorvos and carbofuran were classified as Ib by the WHO, and the Government of Nepal banned them in 2018 because of their negative impact on the environment (PQPMC, 2020). Similarly, Aluminium phosphide was classified as NC by the WHO, which was banned by the Government of Nepal in 2019 (PQPMC, 2020). The use of banned pesticides in this area could be attributed to an illegal import from nearby India via the open border between Nepal and India.

Table 2: Fungicides used in vegetable crops in the study area, including trade names, technical names, active ingredients, formulation, and WHO class

S. N	Trade name	Technical name	A.I %	Formulation	WHO class
1.	All Kraloxyl/M-King	Metalaxyl 8% + Mancozeb 64%	72%	WP	NH
2.	Captan/Boxer	Captan	50%	WP	NH
3.	Celphos	Aluminium phosphide	56%	TAB	NC
4.	Himil	Metalaxyl 8% +Mancozeb 64%	72%	WP	II
5.	Ki-Ram/Surya Thiram	Thiram	75%	WP	II
6.	Ki- Vatavax	Carboxin	75%	WP	III
7.	Vitaxin	Carboxin 22.5% + Thiram 22.5% + Imidacloprid 18%	63%	WP	III
8.	Anti cold/B-protect	Chlorothalonil	75%	WP	NH
9.	Mohini	Copper Oxychloride	50%	WP	III
10.	Bavistin/Goldstin	Carbendazim	80%	WP	NH

Though the Nepalese government registered 14 biopesticides and 13 herbal pesticides (PQPMC, 2020), this study found that vegetable growers did not use them in their vegetable crops. Biopesticides and herbal pesticides are safe for the environment. However, several vegetable growers used homemade herbal mixtures in their crops. Its use was limited to a few vegetable growers since preparing herbal formulation takes time and is less effective against pests than chemical pesticides.

Table 3: Herbicides used in vegetable crops in the study area, including trade names, technical names, active ingredients, formulation, and WHO class

S. N	Trade name	Technical name	A.I %	Formulation	WHO class
1.	Menaka 71/Aandhi-71/Anu 71	Ammonium salt of Glyphosate	71%	SG	III
2.	Novelty Gold/Aquila/Junon	Bispyribac sodium	10%	SC	III
3.	Anu weed/Rugo	2,4-D Ethyl Ester	38%	EC	II
4.	Weedor/Nagrodar	2,4-D Ammonium salt	58%	SL	NH

Abbreviations: A.I.- Active ingredient; EC- Emulsifiable concentrate; SL- Soluble concentrate; SC- Suspension concentrate; SG- Soluble granules; TAB-Tablet; WP-Wettable powder.

Effect of pesticide use on the health of vegetable growers

This study found that vegetable growers used insecticides, fungicides, and herbicides to protect their crops from pests and boost crop yield. However, they apply these pesticides in larger quantities and an unsafe manner, without wearing personal protective equipment (PPE), gloves, spectacles, a face mask, or gum boots. According to the Pesticide Management Directory (2070), they have to protect their entire body by putting on a plastic apron, PVC protective gloves, plastic shoes, glasses, and full-length shirts and pants while spraying pesticides. According to Atreya et al. (2012) several farmers are still uninformed of proper pesticide use, labeling, and hazard levels. Almost fifty percent of vegetable growers use pesticides 5 to 6 times during a single crop cycle (Shrestha et al., 2010). The majority of farmers use pesticides up to four times each month (Khanal and Singh, 2016). Nyaupane (2021) found greater levels of cypermethrin residues in tomato and brinjal compared to the acceptable threshold. As a result, vegetable growers may be exposed to a variety of health risks, including respiratory tract irritation, asthma, skin problems, eye irritation, neurological disorders, gastrointestinal issues, etc.

Out of the 150 respondents, most of the vegetable growers (40%) experienced respiratory tract irritation, followed by skin disorders (20%), asthma (13%), gastrointestinal disorders (12%), eye irritation (10%), and neurological effects (9%) in the study area (Fig. 2). Inhaling pesticide aerosols or vapor causes respiratory tract irritation, which includes sneezing, coughing, sore throat, nasal congestion, shortness of breath, chemical pneumonitis, and so on. Face masks can help minimize respiratory tract irritation, however, it was found that most vegetable growers did not use them during pesticide spraying. Similarly, when pesticides come into contact with the skin, they can cause redness, itching, swelling, and blisters. Chemical burning causes pain, redness, blistering, and peeling of the skin. In severe cases, permanent skin damage or scarring may ensue. Furthermore, gastrointestinal disorders include nausea, vomiting, abdominal pain, and diarrhea, while neurological effects include memory loss, cognitive decline, headaches, dizziness, and so on.

Vegetable growers used various chemical groups of pesticides in the study area. This study found that vegetable growers with a long history of using pesticides suffered from some chronic diseases like asthma, skin cancer, and lung cancer. According to Nyaupane (2021) human disorders like immunological dysfunction, kidney damage, and carcinoma are on the rise in this nation, possibly due to increased usage of insecticides in agriculture. Being exposed to organochlorine pesticide residue may increase the risk of type-2 diabetes (Airaksinen et al., 2011), thyroid problems (Freire et al., 2011), the development of gallstones (Su et al., 2012), hormone-related malignancies (e.g., breast, prostate, abdomen, and lung cancer) (Wolff et al., 1993), and neurological disorders (Forns et al., 2012).

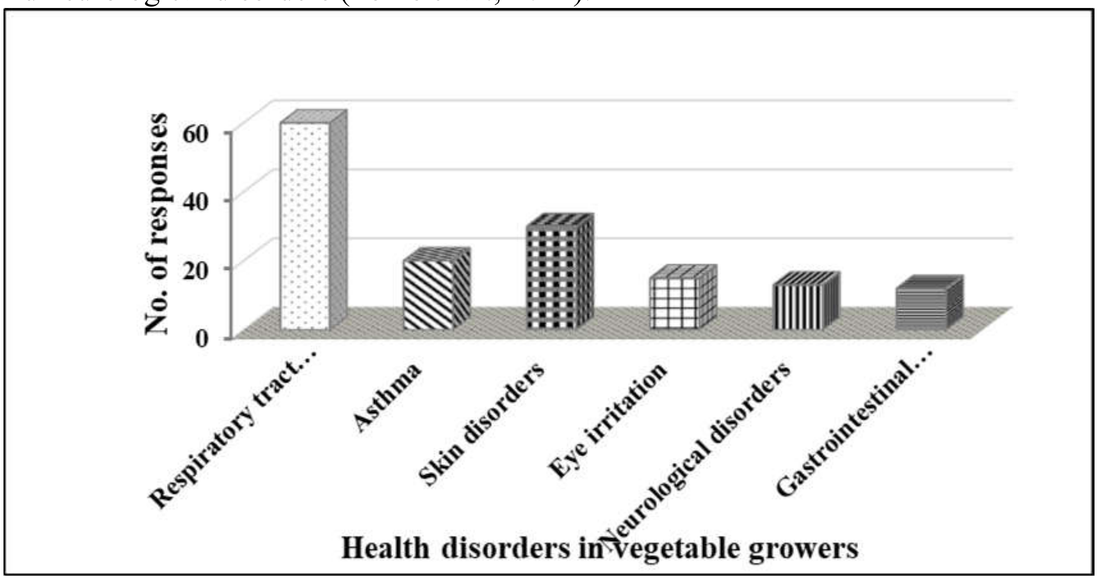

Fig. 2 Pesticide-related health problems among vegetable growers in the study area

Effect of pesticide use on the natural environment

Improper use of pesticides in vegetable crops was the main cause of environmental degradation (air, water, and soil) in the study area. Pesticide residues enter the atmosphere via aerosols and reach water bodies and soil via runoff. The foul odor of chemical pesticides has affected the neighboring people living in the study area during pesticide spraying in vegetable crops, particularly on windy days. The wind helps to disperse pesticide aerosols to distant places, resulting in air pollution. According to locals, the number of beneficial insects (e.g., grasshoppers, butterflies, honeybees), frogs, and fish is decreasing in pesticide-sprayed fields and water bodies. This study found that the majority of vegetable growers (46%) were unknown of the environmental pollution caused by the use of pesticides in crop plants; however, 27% reported air pollution, 20% soil pollution, and 7% water pollution in the study area (Fig. 3). It indicates that there is an urgent need to educate people about the detrimental effects of pesticides on the air, water, soil, and living organisms. Moreover, appropriate pesticide container disposal is also critical for reducing pollution of the environment and protecting human health. Vegetable growers/farmers should adhere to the best procedures and local rules when disposing of pesticide containers. Pesticide containers should be entirely cleansed before disposal to remove any residue using the triple rinse or pressure rinse method; however, vegetable growers had no idea of this in the study area.

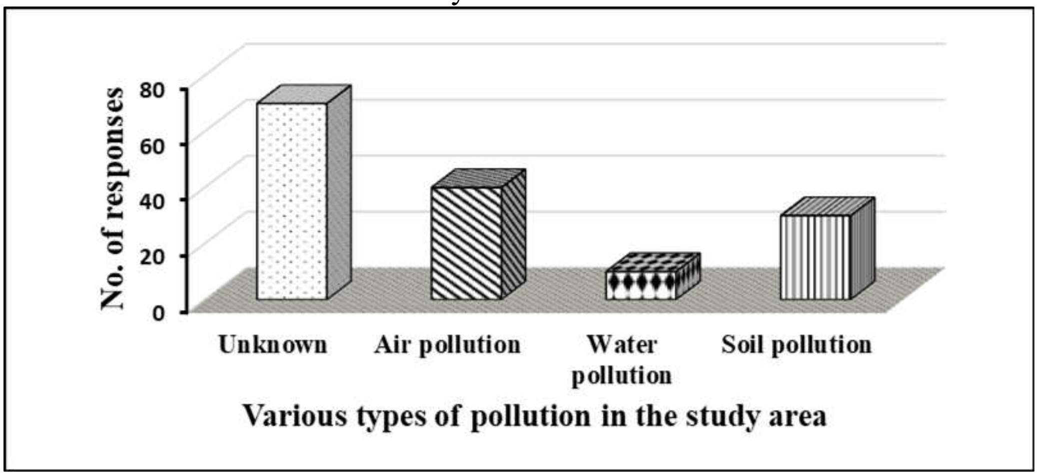

Fig. 3 Various types of environmental pollution due to pesticide use in the study area

This study found that vegetable growers disposed of pesticide containers after use in several ways, including burning them in the open field, burying them in the field, illegally dumping them, selling them to recyclers, storing oil, and storing food products (Fig. 4). The majority of these actions contributed to environmental pollution in the study area. Out of 150 respondents, the majority (47%) of vegetable growers threw pesticide containers in ditches, rivers, canals, and fields, polluting land and water. Another cause of environmental degradation in the study area was the burning of pesticide containers in the fields (28%), which can emit hazardous vapors and residues into the air. Only 3% of vegetable growers buried pesticide containers in the field to prevent pollution. Similarly, 10% of vegetable growers utilized pesticide containers to store food, 7% for oil, and 5% sold pesticide containers to recyclers. Storing food and oil in pesticide containers is risky, especially for human health; it can injure individuals owing to the presence of pesticide residues in the containers. Sharma et al. (2014) showed that 49% of farmers discard pesticide containers by throwing them away, 31% burn/bury them, 18% sell them to market, 1% put oil in them, and 1% store consumables in them. Similarly, according to Tijani (2006) farmers in Nigeria disposed of pesticide containers by burying (25.0%), burning them (10.4%), throwing them into garbage piles (2.1%), and selling them to buyers (25.0%); however, most of them (35.4%) cleaned their pesticide containers for other purposes, such as keeping palm oil.

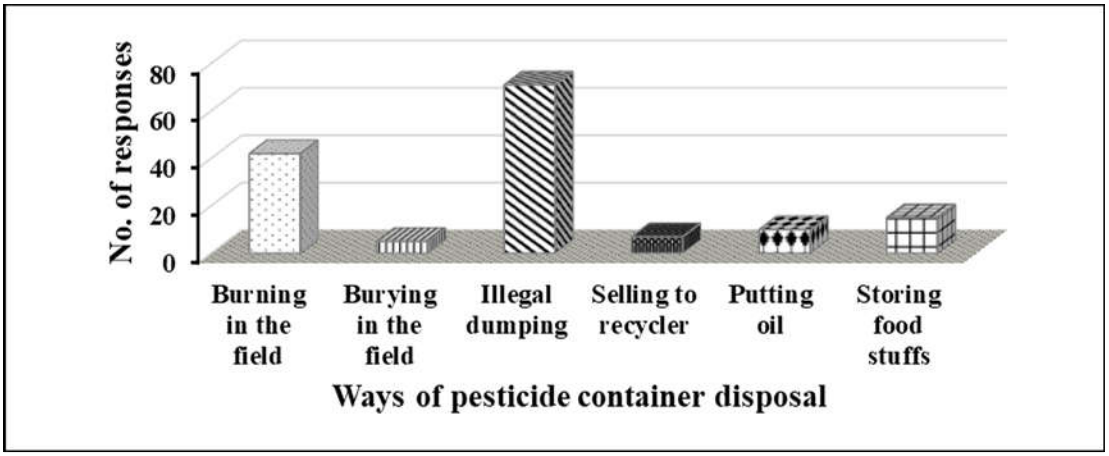

Fig. 4 Various ways of disposal of pesticide containers by vegetable growers in the study area

This study found that regular pesticide usage in the same field with vegetable crops lowered soil fertility, possibly due to the elimination of beneficial microorganisms and other nematodes that serve to promote soil fertility by enhancing soil texture, water-holding capacity, and so on.

Conclusion

Vegetable growers use insecticides, fungicides, and herbicides on their vegetable crops in incorrect and excessive amounts, resulting in environmental pollution and health risks in the study area. Most vegetable growers are unknown of the harmful effects of pesticides on the natural environment and health risks. Some banned pesticides in Nepal are also used by vegetable growers in the Rupandehi district as a result of illegal imports from India. The activity of organizations responsible for pesticide usage, sale, distribution, and management in this district appears ineffective; as a result, there is an urgent need for a thorough investigation into the detrimental effects of pesticides on farmer health and pesticide residues in vegetables. Moreover, this study could provide baseline information for pesticide management and utilization in this area.

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