A Comprehensive Assessment of Pesticide Residues in Two Vegetable-Farming Municipalities in Benguet*

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Abstract

This study is an assessment of pesticide use and its effects on health and the environment in the vegetable-farming municipalities of Kapangan and Buguias, Benguet. It is designed as a participatory action research conducted by Saint Louis University and Benguet State University as part of a wider outreach-research collaboration under the Interuniversity Cooperation Program (IUC) spearheaded by the Flemish Interuniversity Council (VLIR). It is also multidisciplinary in nature, as it brings together the different disciplinal expertise of both universities for a comprehensive assessment of the extent and impact of pesticide use in the identified sites.

For its data gathering, the research utilized interviews, fieldwork, diagnostic tests during medical outreach activities, and laboratory tests. Results revealed that farmer-respondents generally adhere to acceptable and safe procedures on the use of pesticides; all vegetable samples, except for one, did not contain pesticide residues above the maximum residue limit (MRL); water sources were not contaminated and there was no incidence of organophosphate toxicity among farmer-respondents. Findings were fed back to the collaborating local government units (LGUs) as bases for monitoring, follow-up and advocacy.

Keywords: *institutional collaboration, pesticide residues, interviews, laboratory analysis, diagnostic approach, research-outreach*

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INTRODUCTION

The application of pesticide in farms and gardens is a common practice among farmers. Most pesticides are chemicals that are used in agriculture for the control of pests, weeds, or plant diseases (World Health Organization, 1990). After a pesticide is applied, it may meet a variety of fates (Miller, 1999). The residues are left on the sprayed surfaces of the crop. It may be lost to the atmosphere, carried away to surface waters through run-off and erosions or leached downward into the soil. In effect, most pesticides create some risk or harm to people, animals, or the environment.

Farm workers in developing countries are especially vulnerable to pesticide poisoning because most pesticides are applied by hand, the use of protective equipment is rare, children play in fields treated with pesticides, and, worse, some families reuse pesticide containers to store food and drinking water (Miller, 1999). An earlier study on Benguet farmers revealed, too, that they frequently exceed the pesticide dosages, apply pesticides close to the time of harvest, use mixtures of several pesticides, or fail to read and follow labels and instructions (Cheng, 1997).

It is the awareness of the effects and threats that pesticide use can pose on human health and the environment that prompted the conduct of this study. The objective is to assess the practices and extent of pesticide use by farmers, the presence and quantity of pesticide residues in selected crops, soil and water samples, and the level of organophosphate pesticide toxicity in the farmer-respondents as determined by the cholinesterase test. Specifically, the research sought answers to the following questions:

1. What are the practices of the farmer-respondents on the use of pesticide?
2. What are the concentrations of pesticide residues in vegetable, soil and water samples?
3. What is the level of organophosphate pesticide residue toxicity among farmer-respondents as indicated by the cholinesterase test?
4. What symptoms associated with pesticide use were reported by farmer-respondents and verified through medical consultations and clinical laboratory diagnostic procedures?

For the study sites, the researchers chose two vegetable farming municipalities in Benguet, namely, Kapangan and Buguias (see Figure 1). These two municipalities engage in vegetable farming for both subsistence and income generation, thus, the quantity and the quality of the vegetable products are of utmost concern to them.

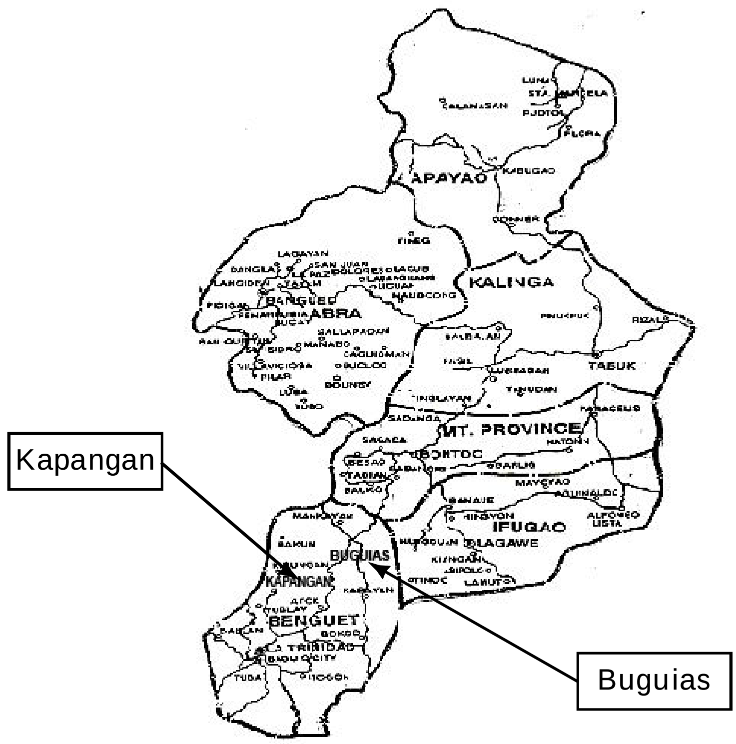

Figure 1. Map of the Cordillera Administrative Region

DESIGN AND METHODOLOGY

This study is designed as a participatory action research, which is a component of a larger framework of partnership for research and extension-community development among academic institutions in cooperation with local government units (LGUs). On the side of the academe, the collaborators are Saint Louis University and Benguet State University, who have a standing outreach-research partnership under the Flemish Interuniversity Council Program (VLIR). The partnership encompasses teaching, research and extension particularly in the aspects of health and environment. This is made possible by the distinct expertise of each university – SLU as a private institution excelling in the health sciences, and BSU as a state university and center of excellence in agricultural education. In terms of this particular research, the partnership amounts to a multidisciplinary approach, as the two institutions bring their respective lenses to work together on the problem of pesticide use and its effect on health and the environment.

The cooperation of the LGU partners – the people and municipal leaders of both Kapangan and Buguias – was indispensable to the conduct of this research-outreach project. As a participatory action research, the planning, implementation and output dissemination were all done with the active involvement of the concerned stakeholders so as to ensure that the target populations benefit from the collaborative endeavor. Moreover, research activities were intertwined with outreach and extension services. At the end of the study, all gathered data as well as the results of the analyses on the status of the crops, soil, water, and health of the farmers related to pesticide use were presented and submitted to the municipal officials and health and agricultural officers for advocacy and policy formulation.

To address health and environmental concerns more comprehensively, different methods of data gathering were utilized. Firstly, needs analysis was conducted through interviews with farmers and family members as well as consultations with key persons, municipal officials and school administrators. Secondly, diagnostic tests were done during the medical-dental outreach activities. Blood samples were collected from the farmer-respondents for the cholinesterase test and complete blood count (CBC). The cholinesterase test is a toxic-specific laboratory analytical procedure for organophosphate pesticide toxicity. The medical history of the patients was also taken to identify possible previous pesticide poisoning.

Thirdly, samples of soil, water, and vegetable were collected from pre-identified collection sites in the two municipalities. Standard collection procedures were strictly followed. These samples were subjected to laboratory analysis, using gas chromatography to determine the level of pesticide residues in them (Curtis, 1987)

RESULTS AND DISCUSSION

Practices of Farmers in the Use of Pesticide

The result of interviews with 102 farmer-respondents from Kapangan and 91 from Buguias regarding their practices on pesticide use are summarized in the succeeding tables and discussions.

Table 1. Profile of respondents according to type of pesticides used

Municipality	Type of Pesticides					
	Insecticides		Fungicide		Weedicide	
	F	%	F	%	F	%
Kapangan N= 102	102	100	65	63.73	50	49.02
Buguias N= 91	89	97.8	85	93.4	62	68.13

In both municipalities, most farmers use insecticides, fungicides and weedicides. Based on the percentage of respondents, more Buguias farmers use varied pesticides as compared to those of Kapangan. Some also indicated the use of rodenticide. Most respondents applied pesticides as needed or every three days, or every week.

Table 2. Use of protective gear

Municipality	Boots		Gloves		Face Mask		Goggles		Coveralls		No Protective Gear	
	F	%	F	%	F	%	F	%	F	%	F	%
Kapangan N= 102	60	58.82	8	1.84	44	43.13	15	14.70	9	8.82	36	35
Buguias N= 91	83	91.20	40	43.95	20	21.97	8	8.79	16	17.58	5	5

To protect themselves, most farmers use boots. More respondents from Buguias practice the wearing of gauntlet gloves and coveralls, while more Kapangan farmer-respondents wore facemasks and goggles. The data also show that very few farmers use more than one type of protective clothing. There were a total of 41 farmers who reported not using any protective clothing at all.

Table 3. Length of time respondents have used pesticide

Municipality	20 years and more		10-19 years		Less than 10 years	
	F	%	F	%	F	%
Kapangan N= 102	25	24.5	24	23.53	54	51.96
Buguias N= 91	24	26.37	23	25.27	44	48.35

A higher percentage of farmer-respondents from Buguias have been using pesticides for more than 20 years, as compared to Kapangan respondents. The majority, however, have used pesticides for less than 10 years.

Almost all the pesticide users employ the knapsack system. They further reported that they perform the three pesticide-related activities, namely, mixing, loading and spraying where they experienced spillage on various parts of the body, mainly, the hands, arms and back. The findings also show that farmers learned about pesticide use from informal talks, seminars, and printed materials.

Concentration of Pesticide Residues in the Environment

Pesticide Residues in Soil

The environmental fate of pesticides in the soil is viewed with great concern. It has been calculated that 50% of the pesticides sprayed on crops or used as a herbicide misses its target and falls on to the soil (WHO, 1986). Some pesticides, notably organochlorines, may persist in the soil for years (Edwards, 1986) although a large proportion evaporates. The persistence and transport of pesticides in soils depend on several factors such as the chemical structure of the compound, type of formulation, type of soil, weather conditions, irrigation, type of crop, and the microorganisms present in the soil.

Table 4. Pesticide Residue Analysis of Soil Samples from Two Benguet Municipalities

Pesticide Active Ingredient (mg/kg)	Kapangan Soil Sample – mg/kg	Buguias Soil Sample – mg/kg
1. Organophosphates		
- Diazinon	ND*	ND*
- Dimethvate	ND	ND
- Methyl Parathion	ND	ND
- Fernithrtion	ND	ND
- Chlorpyrifos	0.15 (S3)	0.03 (S2) 0.05 (S5)
- Malathion	ND	ND
- Penthoate	ND	ND
- Profenofos	0.55 (S3) 0.05 (S6)	ND ND
- Triazyphos	ND	ND
2. Organochlorines		
- Dieldrin	ND	ND
- Chlorothalonil	0.02 (S4)	ND
- Heptachlor	ND	ND
- Lindane	ND	ND
- Aldrin	ND	ND
- A Endosulfan	ND	ND
- B Endosulfan	ND	ND
- Endosulfan Sulfate	ND	0.07 (S1), 0.30 (S2), 0.11 (S4)
3. Pyrethroid		
- Cyalothrin	0.01 (S3)	0.06 (S2)
- Permethrin	ND	ND
- Cyfluthrin	ND	ND
- Cypermethrin	0.05 (S3)	0.06 (S2)
- Fenvalerate	ND	0.04 (S4)
- Deltamethrin	ND	0.03 (S2) 0.06 (S3)

Minimum Limit of Determination:
< 0.01 mg/kg for organophosphates
< 0.005 mg/kg for organochlorines and pyrethroids
* None detected at the limit of determination.

Results of gas chromatographic analysis of six soil samples collected from each of the two municipalities, revealed the presence of pesticide residues. Soil sample #3 from Kapangan contains two types of organophosphate residues (chlorpyrifos and profenofos) and two types of pyrethroid residues (cyalothrin and cypermethrin). Sample #4 from the same municipality contains the organochlorine residue chlorothalonil and soil Sample #6, an organphosphate residue, profenofos. Soil Sample #2 from the Buguias municipality contains five different residues, namely one organophosphate (chloripyrifos), one organochlorine (endosulfan sulfate), and three pyrethroids (cyalothrin, cypermethrin, and deltamethrin). Soil sample #4 contains two different pesticide residues, one organochlorine (endosulfan sulfate) and one pyrethroid (fenvalorate). Soil samples #3 and 5 had one type of residue each, organophosphate (chlorpyrifos) and one pyrethroid (deltamethrin) respectively.

Pesticide Residues in Water

Water samples were collected from the same sources as the soil and vegetables used in the study. All samples were analyzed through gas chromatography for the presence of pesticide residues.

Table 5. Pesticide Residue Analysis of Water Samples

Pesticide Active Ingredient (mg/kg)	Water Samples (mg/kg)
1. Organophosphates	
- Diazinon	ND
- Dimethvate	ND
- Methyl Parathion	ND
- Fernithrtion	ND
- Chlorpyrifos	ND
- Malathion	ND
- Penthoate	ND
- Profenofos	ND
- Triazyphos	ND
2. Organochlorines	
- Dieldrin	ND
- Chlorothalonil	ND
- Heptachlor	ND
- Lindane	ND
- Aldrin	ND
- A Endosulfan	ND
- B Endosulfan	ND

Pesticide Active Ingredient (mg/kg)	Water Samples (mg/kg)
3. Pyrethroid	
- Cyalothrin	ND
- Permethrin	ND
- Cyfluthrin	ND
- Cypermethrin	ND
- Fervalerate	ND
- Deltamethrin	ND

Remarks: As per sample received. Results obtained by gas chromatography.
* None detected at the limit of determination (LOD)
< 0.03 mg/kg for Organophosphates
< 0.005 mg/kg for Organochlorines and Pyrethroids

No pesticide residues were detected from all the water samples at the limit of determination (LOD) which is < 0.03 mg/kg for organophosphates and < 0.005 mg/kg for organochlorines and pyrethroids.

Pesticide Residues in Vegetables

Quantitative analysis using gas chromatography was used to determine the concentrations of the pesticide residues in the selected crops from Kapangan and Buguias. The concentration is then compared with the maximum residue limit (MRL) which is the quantity of residues considered safe for human consumption. The MRLs are usually used by the Codex Committee on Pesticide Residues (CCPR) in setting maximum residue limits (Codex MRLs) for pesticide residues on commodities in international trade (WHO, 1990).

Table 6. Quantitative Analysis of the Plant Samples of Kapangan, Benguet Using Gas Chromatography

Laboratory Code	Sample	Active Ingredient (mg/kg)	Maximum Residue Limit (MRL) (mg/kg)
Bg-SPR-04-027	Gabi 1	ND*	—
Bg-SPR-04-028	Gabi 2	ND	—
Bg-SPR-04-029	Gabi 3	ND	—
Bg-SPR-04-030	Pechay1	ND	—
Bg-SPR-04-031	Pechay2	Cypermethrin 0.30	—

Remarks: As per sample received. Results obtained by gas chromatography.
* None detected at the limit of determination (LOD)
< 0.03 mg/kg for Organophosphates
< 0.005 mg/kg for Organochlorines and Pyrethroids

Based on the results above, only one vegetable sample was identified to contain a pyrethroid residue, cypermethrin, with the quantity of 0.30 mg/kg. Since there is no MRL for cypermethrin in pechay, it cannot be determined whether this amount is beyond the safe level for human consumption.

Table 7. Quantitative Analysis of the Plant Samples of Buguias, Benguet Using Gas Chromatography

Laboratory Code	Sample	Active Ingredient (mg/kg)	Maximum Residue Limit (MRL) (mg/kg)
Bg-SPR-05-001	Potato	ND	
Bg-SPR-005-002	Potato	ND	
Bg-SPR-005-003	Celery	Cypermethrin 0.38	-
		Chlorpyrifos 0.37	0.05
		Profenofos 5.44	-
Bg-SPR-005-004	Celery	Chlorothalonil 0.06	3.00
Bg-SPR-005-005	Cabbage	Deltamethrin 0.04	.05
Bg-SPR-005-006	Pechay	Chlorpyrifos 0.14	1.00
Bg-SPR-005-007	Lettuce	ND	
Bg-SPR-005-008	Carrots	ND	
Bg-SPR-005-009	Pechay	Fenvalerate 0.11	-
		Chlorpyrefos 0.14	-

Remarks: As per sample received. Results obtained by gas chromatography.
* None detected at the limit of determination (LOD)
< 0.03 mg/kg for Organophosphates
< 0.005 mg/kg for Organochlorines and Pyrethroids

More residues were identified from the crops collected from the Buguias municipality. Out of the nine samples, five were tested positive for residues at LOD. However, only one (celery BG SPR-005-003) sample contained an organophosphate residue (chlorpyrifos) with a quantity of 0.37 mg/kg higher than the MRL of 0.05 mg/kg. As there are no MRL values for cypermethrin and profenofos in celery as well as fernvalerate and chlorpyrifos in pechay, it is not possible to identify if the vegetable is safe for human consumption.

Pesticides on crops may evaporate, be washed off, break down or become absorbed into the plant tissues. The concentration also decreases as a result of dilution while the plant grows. Thus, a pesticide application that was initially toxic to humans may, with time, become harmless. For this reason, farmers are advised not to spray just before harvest.

Cholinesterase Test

Cholinesterase is important in the hydrolysis of acetylcholine in cholinergic synapses. Upon hydrolysis of acetylcholine, the transmission of nerve impulses is terminated. Cholinesterase inhibitors act to prevent cholinesterase from effecting this hydrolysis and this results to hyperstimulation of the affected area. Organophosphates form irreversible blockade of cholines—cholinesterase activity in the nervous system. This activity can then be determined through an in-vitro cholinesterase enzymatic assay (Bank and Decker, 1987).

Blood from 152 subjects were drawn for cholinesterase testing. The blood samples were brought to the Notre Dame de Chartres Diagnostic and Pastoral Center in Baguio City. Serum was separated and subjected to cholinesterase test. The normal range of cholinesterase assay is 2150-4950 U/L. The test results show that no subject was found to have decreased levels of cholinesterase, thereby ruling out pesticide poisoning by organophosphates. Increased levels of cholinesterase are not significant in organophosphate poisoning.

Cholinesterase tests have ruled out any indicator that may be associated with organophosphate poisoning among Kapangan and Buguias farmer-respondents.

Symptoms Reported by Farmer-Respondents Related to Pesticide Use

The farmers identified the symptoms they felt after application of pesticides. Based on the results of interviews, the five most common general symptoms are muscle pain, weakness, easy fatigability, fever, and loss of appetite. Common EENT (eyes, ears, nose, and throat) symptoms are eye redness, eyestrain, blurring of vision, itchy eyes and watery eyes. Neurological symptoms reported are dizziness, vertigo and headache while nausea, abdominal pain, and throat irritations were identified for GIT (gastrointestinal tract). A total of 42 respondents said that they suffered from cough after pesticide use while others reported difficulty in breathing and produced wheezing. Twenty-eight respondents experienced chest pain while others had palpitations. Skin disorders were associated with rashes, itchiness, and sweating.

Based on the diagnosis done during the medical-dental outreach conducted in Kapangan and Buguias, the most common ailments among the adults who sought consultation were anemia, acid-related disease, strain and upper respiratory tract infection.

Among the children, the ailments of higher incidence compared to other symptoms were bronchial asthma, bronchitis and malnutrition.

Clinical Tests

Blood samples from 45 respondents were taken for examination. The hematology results are presented in the following table.

Table 8. Hematology Test Results of Farmer-Respondents from Kapangan (November 2004)

Number of Respondents	Findings	Incidence
45	Mild Hypochromasia and Microcytosis	2
	Mild Hypochromasia with Poikilocytosis	1
	Decreased Hemoglobin	4
	Leukocytosis	1

Hypochromasia is a term to describe stained red blood cells that exhibit a large pale central area when viewed microscopically. Microcytosis is a term used to describe red blood cells that are abnormally smaller than the normal diameter of 7-9 micra. This indicates that the two subjects exhibiting this result would most probably be suffering iron metabolism-associated disorders like iron deficiency anemia. This may be attributed to low intake or iron-rich diet. Poikilocytosis refers to deviation from the normal biconcave shape of red blood cells as observed in peripheral smears. Poikilocytosis has also been observed in the smear of one subject. The variations are elliptocytes, ovalocytes, and echinocytes. Based on the clinical correlation, the hematological picture of the patient would be considered iron-deficiency anemia. Mild decrease of hemoglobin-hematocrit levels among four subjects were seen, with one male subject identified to be the same person with mild hypochromasia and microcytosis, and one female subject presented earlier to have mild hypochromasia with poikilocytosis.

Routine hematology tests were also performed for 95 patients at a later date (see results in Table 9). Seven had leukocytosis; four female subjects had normocytic-hypochromic anemia; and 10 females and 19 males fell below hemoglobin-hematocrit standards.

Table 9. Hematology Test Results of Farmer-Respondents from Kapangan (January 2005)

Number of Respondents	Findings	Incidence
95	Leukocytosis	7
	Normocytic-hypochromic anemia	4
	Anemia by hematocrit standards	Males: 10 Females: 19

Leukocytosis is a general finding in a number of different etiologies, pesticide poisoning included. Normocytic-hypochromic (normal size but pale staining property of red blood cells) anemia in four subjects were ruled out as iron-deficiency anemia. These four females are included in the 10 female subjects whose hemoglobin-hematocrit was below the accepted hemoglobin-hematocrit standards for females.

Another set of hematology tests were done among the farmers of Buguias (see results in the table below.)

Table 10. Hematology Test Results of Farmer-Respondents from Buguias (March 12, 2006)

Number of Respondents	Findings	Incidence
156	Normocytic-hypochromic anemia	4

Test results were generally within normal limits with only four patients with iron-deficiency anemia where one of them had abnormal RBC morphology.

As a whole, the relationships among the findings in relation to pesticide use are non-conclusive since there are other factors that affect the health impact of pesticides on man and the environment.

CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn.

1. Most farmer-respondents adhere to proper use of pesticides.
2. Pesticide residues of organophosphates, organochlorines and pyrethroids were detected in soil and vegetable samples. Only one vegetable sample contained residues higher than the maximum residue limit (MRL).
3. The routine laboratory findings and the cholinesterase test have ruled out any indicator that may be associated with organophosphate poisoning.
4. The symptoms reported by the farmers and verified through medical consultations and check ups cannot be directly attributed to pesticide poisoning inasmuch as they can also be symptoms associated with other diseases.

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