

Research paper

Impacts of Pesticides and Fertilizers on Soil, Tail Water and Groundwater in Three Vegetable Producing Areas in the Cordillera Region, Northern Philippines

ABSTRACT

The study focused on the impacts of pesticides and fertilizers on soil and water in three vegetable producing areas in the Cordillera region in the northern central part of the Philippines. Three major vegetable producing communities were selected as study sites with seventy five (75) key informants interviewed. Soil and water samples were obtained to determine the extent of soil and water contamination with pesticides and fertilizers. There was a high level of awareness on the negative impacts of commercial pesticides and fertilizers on soil, water and human health but awareness did not influence the way farmers utilize pesticides and dispose of empty bottles/containers of pesticides after use. Soil samples from Balili, Mankayan, Benguet and Sadsadan, Mt. Province contain variable amounts of pesticide residues in the top 15 centimeter soil surface. The residues detected were: chlorpyrifos, profenofos, cyhalothrin, cypermethrin and fenvalerate. Chlorpyrifos was found in one soil sample in Sadsadan above the Limit of Determination. Similarly, chlorpyrifos, cypermethrin and fenvalerate were found in two soil samples in Balili higher than the limit of determination. No pesticide residue was found in all soil samples obtained from the inner 200 centimeter soil depth. Soils in the garden sites of Tinoc, Ifugao were still pesticide free. Water samples in all the sites contain no pesticide residues but found to contain high levels of coliform bacteria. Pesticide contamination of soil and water was not as severe as anticipated but rather it is the presence of coliform bacteria severely contaminating water bodies in the area. Natural springs unspoiled by human population are still clean and potable. Nitrate levels in soil and water is low but showed some signs of building up due to the continuous application of fertilizers. Hospital records showed no reported cases of pesticide poisoning due to improper handling. However, there were cases of intentional ingestion of pesticides for purposes of committing suicides. Respiratory diseases top the list of the ten leading causes of morbidity in all three study sites. The study site in Tinoc was affected by frequent cases of diarrhea especially during the rainy months.

Key Words: Soil Contamination, Tail Water, Groundwater Contamination, Agricultural Chemicals, Chicken Manure, Total Coliform Bacteria

1. INTRODUCTION

The Cordillera region is home to the largest vegetable industry in the Philippines. It is composed of 6 provinces namely: Benguet, Mt. Province, Ifugao, Abra, Kalinga and Apayao. The region supply 70% of temperate vegetables in the Philippine market chiefly potato, cabbage, beans and carrots [1]. The study covered 3 major farming communities that are found in Benguet, Mt. Province and Ifugao. The farming communities included in the study are: Balili, Mankayan, Benguet, Sadsadan, Bauko, Mt. Province and Tinoc Poblacion, Tinoc, Ifugao. The three study sites differ in terms of the evolution of the gardening industry in each of the sites. In Balili, the vegetable industry started way back in 1957 followed by Sadsadan in 1960 and Tinoc in 1998. Over the years the vegetable industry is known to rely heavily on commercial fertilizers and pesticides. Farmers use fertilizers and pesticides to enhanced yield and control pest and diseases. Aside from chemical inputs, the gardening industry has a long history of using fresh chicken manure to

remedy nutrient deficiencies in the soil. The use of chemical inputs is sometimes concomitant with the presence and persistence of fertilizer and pesticide residues in soil and water. The lingering negative connotation associated with pesticide use led some people to believe that soil and water inside garden areas are heavily polluted with chemical residues detrimental to human health. Still others refuse to eat vegetables believing that they contain high levels of pesticide residues. The study was made primarily to provide evidences to repudiate or affirm some of the prevailing assumptions regarding the impacts of pesticides and fertilizer on soil and water. The main objectives of this study are: 1) to assess the farmers level of awareness on the negative impacts of agrichemicals on health and environment 2) to obtain information on the types of agricultural chemicals used by vegetable farmers, 3) to determine the effects of agricultural chemical on soil and water 4) to identify major sources of pollutants in the area aside from agricultural chemicals and 5) to recommend solutions for mitigating the negative effects of soil and water contamination that affects people's health and their communities. The direct beneficiaries of the study are the vegetable farmers who are handling agricultural chemicals pursuant to their vegetable production. Fertilizers and pesticides are inseparable components of the vegetable industry and growers should know the negative impacts of these farming inputs to soil and water. Farmers themselves and their families including their animals are the ones working with the soil and having access to water resources within the vicinity of their garden areas and it will always result to poor health and even death in the long-term.

Understanding the impact of agricultural chemicals on soil and water quality will have a direct bearing on how farmers should use their agricultural chemicals in such a way that it will not continue to contaminate soil and water resources. It would hopefully raise people's awareness on these important environmental issues and develop mitigation measures to address these issues for the benefit of both present and future generations.

2. MATERIALS AND METHODS

Three vegetable growing barangays in 3 provinces in the Cordillera region were selected as the site of this study. The sites are Balili, Mankayan, Benguet, Sadsadan, Bauko, Mt. Province and Tinoc Poblacion, Tinoc, Ifugao. Twenty five farmers in each of the community were interviewed as key informants. Level of awareness was measured using a 4 point rank order scale such as: not aware (NA), less aware (LA), adequately aware (AA) and very much aware (VMA). Focus Group Discussion (FGD) was used to validate the data that was gathered.

Soil samples were gathered at the upper, middle and lower portion of the garden landscape. A line sampling method was employed for each subunit and 10 subsamples were gathered per subunit. Thus, one composite sample is made up of 10 subsamples. Soil samples were collected from the upper 15 cm soil surface and inner 200 cm soil depth. Grab water samples were collected at the point source of natural springs and at the tail-end of creeks that are found inside the garden areas. Soil samples were brought to the regional analytical laboratory of the Department of Science and Technology in La Trinidad, Benguet, Philippines for analysis. On the other hand, water samples were brought to the National Pesticide Analytical Laboratory in Quezon City, Philippines for the corresponding analysis.

3. RESULTS AND DISCUSSION

3.1 Level of Awareness on the Impacts of Pesticides on Health

Better awareness on the harmful effects of fertilizers and pesticides is the key to the proper handling and disposition of such hazardous materials. To obtain farmers level of awareness on the impacts of pesticides on human, a four point awareness question was floated. On a scale of 1.00-4.49, the farmers' level of awareness on the key issues on the impacts of pesticide were ranked accordingly. Farmer's level of awareness is high ranging from adequate to very much aware indicative of a high level of understanding on the negative association between pesticide utilization and human health. The farmers' level of awareness on the impact of pesticides on human health is shown in Table 1.

Table 1. Farmers level of awareness on the impacts of pesticides on human health

Items of Awareness	Study Sites			Mean	Description
	Tinoc	Balili	Sadsadan		
Pesticides generally affect people's health	3.60	3.41	3.59	3.53	Very Much Aware
Pesticides can cause skin and eye irritation	3.64	3.38	3.52	3.51	Very Much Aware
Pesticides can cause stomach irritation and vomiting	3.60	3.43	3.30	3.44	Adequately Aware
Pesticides can cause dizziness	3.48	3.38	3.56	3.47	Adequately Aware

3.2 Level of Awareness on the Impacts of Pesticides on Soil and Water

Pesticides may influence the quality of soil and water found inside garden areas but may also affect the health of people using these pesticides. With no other recourse, gardeners have to deal with pesticides and herbicides everyday to control pest and diseases and weeds, respectively. The concern for environment and human health relative to the use of hazardous farming inputs are the two important aspects of agriculture. Awareness on the negative impacts of pesticides on environment and human health is the key to the proper handling and utilization of pesticides. To determine the farmer's level of awareness on the impacts of pesticides on soil and water, a seven point awareness question was floated. Using the same scale of 1.00-4.49, the farmer's level of awareness was ranked accordingly. Result indicates that farmer's are adequately aware of the negative impacts of pesticides on soil and water. It is however, evident that farmer's level of awareness on the impacts of pesticides on soil and water appears to be lower compared to their awareness on its impact on human health. It may imply that farmers are more concern in protecting their health when handling pesticides than protecting the environment.

Farmers' level of awareness on the impacts of pesticides on human health and soil and water is high which ranges from adequate to very much aware. However, it appears that awareness did not influence the way farmers handle pesticides in their respective farms. During field work it was observed that farmers do the easy way by putting pesticide bottles along farm corners and boundaries. It was also noted during the field work that farmers do not use adequate protective gears while spraying pesticides. The failure of farmers to use the appropriate protective gears during spraying may have exposed themselves to the risk of pesticide poisoning. However, there were no reported cases of direct poisoning due to pesticide spraying. The only reported cases are intentional ingestion of pesticides particularly gramoxone, sumicidin and some unnamed pesticides for purposes of committing suicide. In Tinoc for instance, there were five cases of suicide attempts from CY 2010-2011. Of the five intentional cases, 4 died and one survived. In Sadsadan, only one case of suicide was reported which occurred in 2008. In Balili, there were 6 reported cases of intentional ingestion from 2008-2010. Fortunately, five (5) of them survive and only one died of complication from high blood pressure. Farmer's level of awareness on the negative impacts of pesticides on environment is indicated in Table 2.

Table 2. Farmers level of awareness on the impacts of pesticides and fertilizer on soil and water

Items of Awareness	Study Sites			Mean	Description
	Tinoc	Balili	Sadsadan		
Pesticides can kill beneficial organisms in the soil	3.16	3.41	2.29	2.95	Adequately Aware

Pesticide can pollute the air we breath	3.28	3.41	3.15	3.28	Adequately Aware
Pesticide can kill fishes and shells in rivers and other water bodies	3.28	3.18	3.52	3.33	Adequately Aware
Pesticide residues can remain for many years in the soil	3.00	3.27	2.59	2.95	Adequately Aware
Pesticide residues can be retained in the vegetables produced	3.24	3.23	3.07	3.18	Adequately Aware
Commercial inorganic fertilizer Makes soil hard and difficult to cultivate	3.24	2.95	2.22	2.80	Adequately Aware
Commercial inorganic fertilizer is carried by rain and pollute rivers/creeks and springs	3.32	3.05	2.33	2.90	Adequately Aware
Scale: 1.00-1.49 Not Aware 3.50-4.49 Very Much Aware					
1.50-2.49 Less Aware					
2.50-3.49 Adequately Aware					

3.3 Pesticides, Herbicides and Fertilizers Used by Farmers in the Three Study Sites

At the time of interview, the three study sites were using ten (10) brands of pesticides, five (5) brands of herbicides and an undetermined number of commercial fertilizers in its solid or liquid form. Of the 10 common brands of pesticides, five of which belong to the pyrethroid class of pesticides, four organophosphate and two under the carbamate class of pesticides. Nobody is using any organochlorine compound but farmers claimed they have been using DDT and Endrin prior to their restriction in the 1980's. On-site utilization of pesticides and other farming inputs is driven by sales agent, farmers' cooperatives and private agricultural traders. With this arrangement farmers have continuous access to the latest information and pesticide being sold in the market. Table 3 shows the pesticides, herbicides and commercial fertilizers used by farmers in the 3 study sites.

Table 3. Pesticides, Herbicides and Commercial Fertilizers used in the 3 Study Sites

Name of Insecticide	Active ingredients	Length of Usage	Class	Name of Herbicides	Name of Commercial Fertilizers
Sumicidin	Fenvalerate	15	Pyrethroid	Power	Urea
Bida	Cyhalothrin	10	Pyrethroid	Gramoxone	Complete Fertilizer (14-14-14, 16-20-0)
Karate	Cyhalothrin	10	Pyrethroid	Clear out	Foliar Fertilizers
Nurell	Cypermethrin	2	Pyrethroid	Afalon	Fresh Chicken Manure
Selecron	Profenofos	5	Pyrethroid	Bio 480	

Tamaron	Methamidophos	10	Organophosphate	Redeem
Silicron	Dimethoate	5	Organophosphate	
Lorsban	Chlorpyrifos	3	Organophosphate	
Cartap	Dymethylamin	10	Carbamate	

3.4 Disposal of Pesticide Waste

The most common type of spraying pesticides in the three study sites is the use of knapsack sprayers. It was observed that some farmers are also using power sprayers. In terms of the management of pesticide bottles, farmers do not follow any definite procedure for disposing these bottles and washing sprayers after use. During the field work, the research team came across empty pesticides bottles piled along farm corners and boundaries. Some of the bottles are partly buried with soil indicating that it had been there for many years. Bottles with leaking rusted caps can be filled with rain water and slowly release poisonous liquid that can leach to underground springs and surface water bodies. In the same manner, farmers washed sprayers in rivers and creeks or to any water they can access such as springs, rice field or irrigation canals. The improper disposal of empty pesticide bottles and indiscriminate washing of sprayers is a direct hazard to soil and water. Safe disposal should become a part of the solid waste management program of the barangay through the Local Government Units (LGU's) pursuant to RA 9003 or otherwise known as the Ecological Solid Waste Management Act of the Philippines. It may also be the responsibility of private salesmen and pesticide dealers to educate gardeners on the proper disposal of toxic chemical waste. The construction of centralized leak proof concrete waste vaults for storing pesticide bottles is one way of containing the indiscriminate disposal of bottles. The different ways by which gardeners dispose of empty bottles of pesticides and clean their sprayers is shown in Table 4-5.

Table 4. Methods of disposal of empty bottles of pesticides employed by farmers in the 3 study sites

Method of Disposal	Study Sites			Total
	Ifugao	Mt. Province	Benguet	
Leave empty bottles				
In the farm	15	21	12	48
Keep the bottles				
at home	3	2	9	14
Leave bottles in				
waste bins	7	2	4	13
Total	25	25	25	75

Table 5. Methods of cleaning sprayers employed by farmers in the 3 study sites

Method of Cleaning Sprayers	Study Sites			Total
	Ifugao	Mt. Province	Benguet	
Washing of sprayers				
in rivers/creeks	13	10	12	35
Washing in spring	2	9	7	18
Washing in irrigation canals	1	5	2	8
Washing in rice fields	9	1	0	10
Total	25	25	21	71

Statistical analysis using the Analysis of Variance (ANOVA) showed no significant relationship between farmers' level of awareness and disposal of pesticide waste. The insignificant relationship confirmed the observation that farmers' level of awareness did not influence the way farmers dispose of pesticide waste. Farmers just do the easy way by just leaving empty bottles of pesticides in the farm or wash sprayers anywhere where they can find water.

3.5 Soil Quality Status of the Three Study Sites

Soil samples were obtained from October to November of CY 2011. Crops grown during field sampling include cabbage, carrots, Chinese cabbage and potatoes. The crops were fertilized with urea and complete fertilizers at least twice prior to soil sampling. The fertility and pH status of soils in the three study sites is shown in Table 6.

Soil pH ranges from moderate to strong acidity. The low pH can be attributed to the excessive use of fertilizers. To raise the pH level it may be necessary for farmers to consider applying lime. The nitrogen (N) content of the soil is low below the typical range of 1.0 percent indicative of nitrogen deficiency. Nitrogen deficiency can be attributed to the high uptake of nitrogen by actively growing vegetables. Farmers ameliorate nutrient deficiency in two ways: the application of commercial fertilizers such as urea and complete fertilizers (NPK), and the application of fresh or semi-decomposed chicken manure. Chicken manure is applied one time per cropping cycle at a rate of 100-120 cavans (35-40 kilos per cavan) per hectare. The vegetable industry is a net importer of fresh chicken manure from the lowlands.

Phosphorous (P) is another nutrient needed by plants in large quantities. The Phosphorous content of soil in the 3 study sites is above the standard limit (Olsen) of 2-60 ppm. The high P content can be attributed to the low pH level of the soil. Under acidic soils, P is fixed by iron and aluminum. Busman et al. [11] pointed out that the low availability of P is very pronounced in acidic soil (pH<5.5) and alkaline soil (pH >7.3). The low pH range of surface soils in the 3 study sites ranging from 4.9-5.7 possibly accounted for the fixation of P in the soil. Recent application of P fertilizer in the area may have contributed to the observed high levels of P concentration in the surface soil. Further lowering of soil pH would mean the greater fixation of P. To enhance the availability of P to plants, farmers may have to raise the soil pH by applying lime.

The typical range of K in soils is from 50-700 ppm with greater than 900 considered excessive (<http://www.soiltestlab.com/forms/soil-handout.pdf>). The importance of potassium (K) in ensuring normal growth and production of quality vegetables is well recognized in literatures (Bidari and Hebsur 2011, Kanwar 1976). In all the study sites, the soils contain small amounts of K nutrients below the minimum level. The inadequate concentration of K in the garden soil is indicative of the rapid uptake of K during and in between the active growth stages of vegetables. K deficiencies can be ameliorated through the application of K fertilizers in its pure or mixed with other nutrients.

Magnesium (Mg) is a secondary nutrient needed by plants in large quantities that are typically readily available in the soil. The typical range of magnesium in soil is from 2-30 me/100g soil. The relatively newer garden soil in Tinoc contain higher amounts of Mg than the older garden soils in Balili and Sadsadan but still below the required minimum Mg level to sustain the normal growth and development of garden crops. The low concentration of Mg in all the study sites can be attributed to the natural properties of Mg nutrients which are quite soluble in water. Their soluble properties may have caused them to deteriorate quickly either by hydrolysis, microbial action or leach into the inner soil layers during watering or rainfall. The soils across all study sites do not contain the required minimum levels of Mg for efficient growth of vegetables. The garden soil is in need of K supplementation through fertilization.

Calcium is another secondary nutrient essential for many plant functions. Calcium is found in many of the primary or secondary minerals in soils. Calcium (Ca) is not considered a leachable nutrient. The typical amount of Ca in garden soil is from 5-50 me/100g soil. In natural soils, the availability of Ca is conditioned by soil pH where soils with higher pH (alkaline soils) have more Ca content than soils with lower pH (acidic

soils). Under intensive gardening, calcium is lost in the soil by the rapid uptake of growing vegetables without replenishment. In other words, the deposition of calcium from decaying plants parts is slow while the rate of depletion is very fast. The newer garden sites in Tinoc have more adequate calcium content than the soils in Balili and Sadsadan. The calcium deficient soils in Balili and Sadsadan can be attributed to many years of repeated cropping and too much extraction of calcium by rapidly growing crops. To replenish the calcium deficient soil, it may require supplementation through fertilization. However, before fertilization, it may be necessary to raise the soil pH toward the neutral range so as to increase the availability of calcium in the soil.

Table 6. Fertility and pH status of the upper 15 cm. and 200 cm. soil depth in the three study sites

Study Sites	Sampling Depth	pH	N (%)	P (ppm Olsen)	K me/100g Soil	Ca me/100g soil	Mg me/100g soil
Poblacion, Tinoc,	Upper 15 cm.	5.7	0.28	73	0.98	9.22	1.71
Ifugao	200 cm.	5.3	0.16	4.3	0.55	6.02	1.84
Sadsadan, Bauko,	Upper 15 cm.	4.9	0.44	176	0.70	3.84	0.39
Mt. Province	200 cm.	4.6	0.40	25	0.43	1.66	0.39
Balili, Mankayan,	Upper 15 cm.	5.4	0.16	80	0.36	4.10	0.79
Benguet	200 cm.	4.7	0.39	1.5	0.44	1.79	0.39

3.6 Pesticide Residues in Soils of the Three Study Sites

Pesticide residues were detected in all composite samples obtained in the surface soils of Balili and Sadsadan. The pesticide residues detected were: chlorpyrifos, profenofos, cyhalothrin, cypermethrin and fenvalerate. The residue chlorpyrifos, cypermethrin and fenvalerate were detected in the soils of Sadsadan and Balili exceeding the Limit of Determination (LoD). The observed higher levels of pesticide residue concentration in soil above the Limit of Determination (>LoD) can be attributed to the current application of these chemicals a few days prior to sampling. The residue chlorpyrifos could have come from Lorsban insecticide, cypermethrin from Nurell, profenofos from Selecron and fenvalerate from Sumicidin. There was no detection of organochlorine compounds in spite of the fact that farmers reported having used them in the 1980's. Garden soils in Tinoc are still pesticide free. No residue was detected in the 200 cm depth implying that pesticides did not leached into the inner soil layers. Most of the pesticides currently in use by farmers are known to have a short half life and given the relatively short half lives of these pesticides, it is likely that residues detected came from current season application and that there was a high probability that it may have degraded prior to leaching into the inner soil layers. The short half-life and degradable nature of pesticides therefore explained the absence of residues in the inner 200 cm soil layer.

Table 7. Pesticide Residues Found in the Garden Soils of Tinoc, Ifugao, Sadsadan, Mt. Province and Balili, Mankayan, Benguet.

Study Sites	Pesticide Residues			Residue Level*	Remarks
	Organochlorine	Organophosphate	Pyrethroid		
Tinoc a. Upper 15 cm	nd	nd	nd	nd	nd
b. 200 cm	nd	nd	nd	nd	nd
Sadsadan a. Upper 15 cm	nd	Chlorpyrifos	Cypermethrin	0.05, 0.009	>LoD, <LoD
		Profenofos	Cyhalothrin	0.01, 0.01	<LoD, <LoD
b. 200 cm	nd	nd	nd	nd	
Balili					

a. Upper 15 cm	nd	Chlorpyrifos, Profenofos	Cypermethrin Cyhalothrin Fenvalerate	0.05, 0.01 0.01, 0.01 0.03	>LoD, <LoD <LoD, <LoD >LoD
b. 200 cm	nd	nd	nd	nd	

**Limit of Determination (LoD) using Gas-Liquid Chromatography: Organochlorine = 0.005 mg/kg or ppm, Organophosphate= 0.02 mg/kg or ppm. Pyrethroid= 0.02 mg/kg or ppm, nd= no detection*

3. Water Quality Status of the Three Study Sites

Grab water samples were collected from point source of natural springs (level 1 spring as defined by DOH AO No. 2007-0012) [2] and tail-end of creeks. Water samples were transported to the BPI- Pesticide Analytical Laboratory in Baguio City for pesticide residue analysis and at the DOST Regional Standards and Testing Laboratory in La Trinidad, Benguet for the other water quality parameters.

The presence of pesticide residue in water make it toxic unsuitable for use by both humans and animals. Laboratory analysis done on water samples did not reveal any traces of pesticides in all the three study sites. It is quite uncommon that after many years of pesticide application, surface water and underground natural springs are still pesticide free. Again, the absence of any pesticide residue in water samples highlighted the short half-life and degradable nature of newly manufactured pesticides being used by farmers. The pervasive assumption that inland waters within garden areas are heavily polluted with pesticides is not true and not supported by the findings of this study. The water quality status of the three project sites is summarized in Table 8.

Table 8. Water quality status of the three study sites (Tinoc, Sadsadan and Balili)

Study Sites	Pesticide (ppm)	Nitrate (mg/L) (LoD=50 mg/L max)	Total Coliform Count (<1.1 MPN/100 ml (PNSDW)	Total Suspended Solids
Tinoc (Creek water)				
• Mulmog creek	nd	0.57	>8 MPN/100 ml	41.6
• Pipingew creek	nd	0.42	>8 MPN/100 ml	0
• Jerry creek	nd	0.41	>8 MPN/100 ml	1.80
Tinoc (Natural spring water)				
• Gadingan spring	nd	1.24	>8 MPN/100 ml	0
• Dangla Spring	nd	<LoD	<1.1 MPN/100 ml	0

			(LoD= 0.18 mg/L)		
	Sadsadan (Creek water)				
	• Cawanagan creek	nd	1.00	>8 MPN/100 ml	0.60
	• Baobao Creek	nd	<LoD		
			(LoD= 0.18 mg/L)	< 1.1 MPN/100 ml	1.70
	Sadsadan (Natural spring water)				
	• Kinawanagan proper				
	Drinking water	nd	0.90	< 1.1 MPN/100 ml	0
	• Mabilig spring	nd	0.24	< 1.1 MPN/100 ml	0.40
	• Baobao spring	nd	1.00	> 1.1 MPN/100 ml	0
	• Saad spring	nd	1.29	> 8 MPN/100 ml	3.90
	• Cawanagan- Sadsadan				
	Spring	nd	0.66	> 8 MPN/100 ml	14.6
	Balili (Creek water)				
	• Dagadag creek	nd	2.77	> 8 MPN/100 ml	0
	• Sil-ak creek	nd	4.39	> 8 MPN/100 ml	2.80
	Balili (Natural spring water)				
	• Dagadag spring	nd	4.91	> 8 MPN/100 ml	0
	• Munoz Spring	nd	< LoD=0.18 mg/L	> 8 MPN/100 ml	0
	• Upper Cada spring	nd	0	< 1.1 MPN/100 ml	0

Nitrate is one of the many determinants of water quality. Clean and healthy water must be free from nitrates or does not exceed the required maximum level of 50 mg/L. Nitrates in drinking water interfere with the ability of red blood cells to carry oxygen. Children and infants are more vulnerable to nitrate poisoning. Babies can turn blue when there is not enough oxygen transported by their blood. Water samples collected from springs and creeks in the study sites contain small amount of nitrates below the Philippine Department of Health (DOH) prescribed maximum allowable nitrate level. Nitrates may occur naturally in soil and water, but there is no doubt that the traces of nitrates found in the water samples may have come from the recent application of commercial fertilizers and chicken manure. The older garden sites of Sadsadan and Balili contain higher amounts of nitrates than the relatively new garden sites in Tinoc. The nitrate levels had not reach toxic levels yet, but there are indications that it will continue to rise as the use of commercial fertilizer and animal manure expands in the future. In another gardening community in Atok, Benguet, Tirado [3] found higher concentrations of nitrate in surface water and ground-wells above WHO recommended minimum standards of 50 mg/1 NO₃⁻ due to the intensive use of nitrogen fertilizers.

Springs/wells are the natural sources of drinking water for the gardening communities. The presence of coliform in natural springs/wells indicates that the wells are prone to fecal contamination. The Philippine National Standard for Drinking Water [2] set the acceptable limit for total coliform count at <1.1 MPN/100 ml of water. Of the total number of creeks and springs sampled, only one spring in Tinoc (Dangla spring) and two springs in Sadsadan (Kinawanagan proper drinking water and Mabilig spring) met the national standard for drinking water of <1.1 MPN/100 ml. On the other hand, only one spring in Balili (upper Cada spring) met the national standards for drinking water. All the other springs sampled contain high levels of coliform bacteria. There were no other sources of pollutants noted in the area such as piggery and poultry projects. In the absence of such point sources of pollutants, it is likely that the source of coliform contamination came from decaying vegetable left in the soil surface or thrown into bodies of water, human waste diverted to these bodies of water and fresh chicken manure applied to the gardens. It is clear that the location of natural springs/wells relative to garden areas and population centers influenced the presence or absence of coliform contaminants. Clean springs and wells in the three study sites remain unspoiled by garden areas and population centers. Their strategic location within the landscape prevents point and non-point pollution from reaching the water sources. Definitely, the intrusion of people and garden areas within these well/spring sites endanger these clean water sources from coliform bacteria. Thus, the communities using

these wells should develop policies and mechanisms to safeguard these wells from human intrusion to maintain its clean and potable water status.

Total Suspended Solid (TSS) are water pollutants made up of suspended materials such as soil, silt, decaying plants and animals, industrial waste and sewage. Total Suspended Solids (TSS) carried by water is indicative of the effect of surface run-off influence by management, vegetation and slope. Water with high TSS has less clarity and may often mean higher concentrations of bacteria, nutrients, pesticides and metals in the water [4]. TSS is often related to turbidity and it can be remedied by flocculation, sedimentation and filtration. The Philippine National Standards for Drinking Water [2] did not specify any standard for TSS but specifically set a standard for turbidity at no higher than 5 NTU. Cole-Palmer International [5] set the maximum standards for TSS at 100 mg/L or 100 ppm using the gravimetric method with soils dried at 103-105 °C.

Some of the creeks and natural springs sampled have zero loads for TSS while others have small amounts of TSS carried with it. Across all three study sites, the TSS load is below the limit set forth by Cole- Palmer [5] at 100 mg/L of water. Farmers mitigate runoff by establishing plot along the contours and planting vegetables densely in each of the plots.

4. CONCLUSION

Farmers apply fertilizers and pesticides to enhance yield and control pest and diseases. It constitutes the major bulk of farming inputs used by the farmers. Although these farming have meritorious impact on crops it may have deleterious effect on both humans and environment. Based on the findings of the study, the following conclusions are drawn:

- Farmers high level of awareness on the negative impacts of pesticides did not influence the way they utilize pesticides and treat pesticide waste.
- Garden soil in the three study site is obviously sick with declining pH range. This can be attributed to the excessive use of fertilizers.
- Pesticide use for many years did not show any severe negative impact on soil and water. The study did not confirm the widespread assumption that soils and inland waters found in garden areas are severely contaminated.
- Coliform bacteria are severely contaminating natural springs and other water bodies. The primary sources of coliform are chiefly fresh chicken manure, decaying plant organics thrown into water bodies and human fecal waste.
- Nitrate levels in water are still below the required limit of 50 mg/l but have the potential to rise due to continued use of nitrogen fertilizers.

5. RECOMMENDATIONS

1. The continued use of fresh chicken manure and the disposal of vegetable organics in soil and water coupled with human waste should be discouraged. A solid waste management program addressing these issues should be developed through the intervention of the Local Government Unit and the Department of Health. For chicken manure, it may be necessary to process these fresh manures into safer forms of organic fertilizers before they are use in the gardens.
2. Best Management practices should be observed in the utilization of commercial fertilizers and manures to mitigate the contamination of wells and springs with coliform bacteria and deposition of nitrates. The one time application of fertilizers and chicken manure should be discouraged to be replaced by split applications. This will enable crops to absorb all the nitrogen content of applied fertilizers before another split application is done.
3. Water quality surveillance should be in place in all vegetable producing areas to continually evaluate the microbial quality of water. Water quality surveillance will ensure that springs/wells or centralized water system used by gardening communities are free from diseases causing organisms as a pro-active response to possible outbreaks that may result from water borne pathogens.

4. Gardeners to consider using organic fertilizers that satisfied organic safety requirement as a substitute to fresh chicken manure. This would help reduce coliform contamination of water bodies and at the same time improve soil tilth.
5. Farmers need to consider mitigating acidity by the application of lime prior to cropping.
6. There is a need to inform individual households to treat their drinking water by boiling to eliminate existing pathogens. For the clusters of households using centralized water distribution systems, treatment with chlorine may be necessary to remove water borne pathogens.
7. It is also necessary for communities with clean natural springs to develop policies at the barangay level to protect and safeguard these wells by adopting barangay resolutions to declare them off-sites to gardening and human settlement to protect its potable water status.

COMPETING INTERESTS

Author declared that no competing interests exist.

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