International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 4 Number 10 (2015): Pages 977-987
ISDS Article ID: IJDS15042201

Effect of farmers' attitude, usage pattern and handling of pesticides on potable water quality in northern Ghana

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Abstract

The study assessed smallholder cotton farmers' attitude, usage pattern and handling practices of pesticides in the Savelugu-Nanton Municipality. The study identified the most used type of pesticides in the area and their residue levels in drinking water bodies. Farmers' attitude and handling practices of these pesticides were also established. The study sampled 100 farmers across 20 communities in four zones within the Municipality. Water samples from twelve (12) boreholes and four (4) hand dug wells from these communities were analyzed for traces of pesticides used by the cotton farmers. The study found that though *Cypermethrin*, *Acetameprid, Flubendiamide, Profenos, Beta-cyfluthrin, Imidacloprid and Chlorpyrifos* were detected in water samples across most zones, *Cyhalothrin* was the highest in western and northern zones (WZ=1.74μg/L and NZ=1.70μg/L) and exceeded the Ghana Standard Authority (GSA) maximum limits of 0.5μg/L and 0.1μg/L acceptable limit of the European Economic Commission Standard for drinking water. The study also found poor attitude of farmers in the usage, storage and disposal of pesticides by cotton farmers in the Municipality. The study therefore recommended that Government should give regulatory approval and promote the production of Bt cotton among famers to reduce the amount of pesticides used by cotton farmers in Ghana.

Keywords: Cotton, Pesticides, Residue Level, Drinking Water Quality; Farmer Health

Cite this article as: Abdulahi, A., Obiri-Danso, K. and Mohammed, S. (2015), "Effect of farmers' attitude, usage pattern and handling of pesticides on potable water quality in northern Ghana", *International Journal of Development and Sustainability*, Vol. 4 No. 10, pp. 977-987.

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1. Introduction

Cotton is the world's most important non-food agricultural commodity, yet it is responsible for the release of numerous chemical insecticides each year, of which more than 50 percent are considered toxic and hazardous by the World Health Organization (Environmental Justice Foundation, 2007). Cotton is seen as one crop that can be used to fight poverty in resource poor communities in developing countries. Predominantly members of the rural poor, cultivate cotton on plots of less than one-half hectare, or on part of their farms, as a means of supplementing their income. In Ghana, cotton is a cash crop and income earner for farmers in Northern, Upper West and Upper East regions where poverty is endemic. The potential for these principal cotton producing regions to increase their output are undermined by voracious seasonal attacks of their cotton fields by insect pests and diseases as well as unfavorable policy environment, poor sector organization, lack of professionalism of stakeholders, and weak cotton farmer organizations. As a result, from a peak of 38,000 tons in 1999, seed cotton production collapsed to 2,500 tons in 2010.

The Government of Ghana attempts to rescue cotton production established three cotton production zones (North Eastern zone, North Central zone and North Western zone) and entered into transitional agreements with private companies to replace the role of the parastatal Ghana Cotton Company which at the time had a monopoly over cotton production. These companies are responsible for the provision of inputs, purchase of seed cotton, ginning and commercialization of the cotton lint. The major composition of inputs these companies provide are mainly insecticides, pesticides and fertilizers. This resulted in farmers using insecticides from different chemical classes to control insect pest on their cotton farms of which the type of insecticide used is dependent on the region that the farm is located. For instance, Abudulai et al. (2006) reported that Organochlorine insecticides such as Callisufan and Endosulfan are those commonly used in the Northern and Upper East Regions whereas farmers in the Upper West Region generally used Organophosphates such as Dursban (Chlorpyrifos) and Pyrethroids such as karate (Lamda-Cyhalothrin) as well as insecticide mixtures such as Novabol (profenofos+cypermethrin). Some products have the same active ingredients but are marketed under different trade names to farmers across the regions (Abudulai et al., 2006). These insecticides are used either as emulsifiable concentrates (EC) or ultra-low volume (ULV) concentrations. Majority of farmers in the Northern and Upper West regions applied five (5) sprays while those in the Upper East region applied four (4) sprays during a season. Control practices in cotton production generally starts from the vegetative stage and ends at squaring (Abudulai et al., 2006). It is estimated that 80-90 percent Ghanaian farmers who reside in rural areas are using chemical insecticides or weedicides to control insect pests, diseases and weeds on their food and cash crop farms beyond cotton (NPASP, 2012).

Hazardous insecticides are applied to cotton grown worldwide but their negative impact on human health is visited disproportionately upon those living and working in developing countries owing to low levels of safety awareness together with lack of access to and/or money for protective clothing, poor labelling of insecticides, unsafe storage and misuse of used containers, illiteracy and chronic poverty exacerbate the damage caused by cotton insecticides among these low income communities (Palis et al., 2006; Sanfilippo and Perschau, 2008). Even farmers who are aware of the harmful effects of insecticides are sometimes unable to translate this awareness into practice (Damalas et al., 2006; Isin and Yildirim, 2007). It is estimated that worldwide there are more than 26 million human pesticide poisonings with about 220,000 deaths per year (Richter, 2002). Human health effects are often caused by 1) Skin contact: handling of pesticide products, 2) Inhalation: breathing of dust or spray and 3) Ingestion: insecticides consumed as a contaminant on/in food or in water. Farm workers have special risks associated with inhalation and skin contact during preparation and application of insecticides to crops. However, for the majority of the population, a principal source is through ingestion of food which is contaminated by insecticides. Degradation of water quality by pesticide runoff has two principal human health impacts. The first is the consumption of fish and shellfish that are contaminated by insecticides and that this can be a particular problem for subsistence fish economies that lie downstream of major agricultural areas. The second is the direct consumption of pesticide-contaminated water. The pesticide residues exerting serious effects on human health enter the water supply through leaching from soil into ground water (Anju et al., 2010).

However, pesticides usage is wide spread among resource-poor cotton farmers in the northern part of Ghana. Extension is not readily available to the cotton farmers, leaving them with no choice but to rely on traditional forms of farming practices and misapplication of the insecticides which may not be sustainable. To compound the farmers' woes, neither insecticides handling practices among these cotton farmers is properly monitored nor is the type of insecticides used on farmers' fields are properly regulated. The fact that surface and ground water is the main source of drinking water in most of these farming communities give course for concern. The potential health risk associated with miss-handling of these insecticides could cause Ghana loss of farm-hands and its attendant consequence of low productivity due to ill-health and deaths that might result from residual chemical poisoning from consumption of toxic chemicals. This paper therefore assessed cotton farmers' attitude, usage pattern and handling practices of pesticides and their residual levels in water bodies close to cotton farms and its health implications in one of the highest cotton growing districts in Ghana, the Savelugu–Nanton Municipality of Northern region.

2. Materials and methods

The study conducted a preliminary field survey over one month period during the beginning of the cotton growing season (August -September, 2012) and towards the end of the season (November 2012- January, 2013) to have a general overview of the entire cotton production system in the study area. The Municipality was then divided into four zones namely; the Northern zone, Southern zone, Eastern and the Western zones. Five communities were selected from each zone and five cotton farmers interviewed from each of these communities. In all the study interviewed a total of 100 cotton farmers from 20 selected communities using questionnaires. The study also collected secondary data from Savanna Agricultural Research Institute (SARI) and the cotton companies operating in the Savelugu-Nanton Municipality. Data was collected on types of insecticides available and use by cotton farmers in the Municipality obtained from farmers and cotton companies. Data on pesticide handling practices was obtained from farmers using questionnaires and personal observations from the field survey. Areas critically observed include: attitude to insecticide labels, storage of insecticides, sources of insecticides commonly used by famers, protective materials, mixture and quantities, application methods, disposal of empty pesticide containers and dosages used by farmers.

Recommended practices for various insecticides were obtained from pesticide labels and cross-referenced with those conventionally used by farmers. All insecticides were grouped appropriately as weedicides, herbicides and insecticides. The active ingredient, the target organism and the trade name of each pesticide used were recorded. An album of common insecticides used by the cotton farmers in the Northern region was compiled to facilitate the identification process.

The study also identified water bodies which were close to cotton farms and served as sources of drinking water for residents were selected for the study. Triplicate water samples were collected from sixteen (16) waterholes consisting of twelve (12) boreholes and four (4) hand dug wells for laboratory analysis. Water samples were transported to the laboratories of the Ghana Standards Authority (GSA) in a cool box with ice packs to test for the presence and concentration levels of organophosphates and pyrethroids residues in the water samples. The socio-demographic data was analyzed using Statistical Package for Social Sciences (SPSS) and Excel spreadsheet.

3. Results and discussions

3.1. Age and educational level of cotton farmers

The results showed that majority 78 percent of cotton farmers interviewed were within the age category of 19-60years (Table 1). This implies most of the farmers were in their active working ages, meaning sustained labour force exist in Savelugu-Nanton Municipality for continuous cotton production. It however, emerged during the interview that cotton farmers within the age category of 60+ participated in cotton production activities to have access to agro-inputs such as fertilizers, insecticides and tractor plough services for their food crop production other than cotton.

Table 1. Age and educational level of cotton farmers

Age range	**Number of Farmers (%)**
15-18	3
19-60	78
60+	19
Educational Level	
No education	79
Basic education	12
Secondary	3
Tertiary	1
Others (Non-formal education)	5

Source: Field Survey Data, January, 2013

Illiteracy rate among cotton farmers in the district was as high as 79 percent and many have never received any form of formal education (Table 1). This could result in farmers' inability to read, comprehend and follow label instructions of various insecticides use.

3.2. Types of pesticides used by cotton farmers

The study revealed that farmers used pesticides from different chemical classes to control insect pest on cotton in the Municipality (Table 2). Some of the products had the same active ingredients but they were marketed under different trade names to farmers confirming Abudulai et al. (2006) findings that pesticides with same active ingredients are marketed under different trade names to farmers in the Northern part of Ghana. The type of pesticide used was largely dependent on what was provided by the cotton company. However, there were instances where the cotton companies delayed in delivering pesticides to famers that resulted in some farmers using pesticides recommended by neighbours and what was readily available on the market.

Table 2. List of pesticides used by cotton farmers

Trade name	Active ingredient	Category of pesticide
Armada	Lambda Cyhalothrin	Pyrethroids
Dursban	Chlorpyriphos	Organophosphate
Tihan	Flubendiamide/Spirotetramate	Class II
KD 14	Cyhalothrin	Pyrethroids
Chemaprid	Cypermethrin/Acetamiprid	Pyrethroids
Armaphos	Chlorpyrifos	Organophosphate
Pawa	Cyhalothrin	Pyrethroids
Polytheriyn C	Profenos/Cypermethrin	Organophosphate/Pyrethroids
Thunder	Beta-Cyfluthrin/Imidacloprid	Pyrethroids

Source: Field Survey Data, January, 2013

The most used pesticide type was *Pyrethroids* followed by *Organophosphates* and pesticides mixtures (Table 2). This finding disagrees with Abudulai et al. (2006) earlier report that Organochlorine insecticides such as Callisufan and Endosulfan are the most commonly used insecticides in the Northern region. Farmers however, confirmed that variation in terms of the type of pesticide used by cotton farmers from time to time is largely determine by the cotton company that contract the farmers to produce cotton for them. Farmers also reported that some of the pesticides supplied to them by the cotton companies were ineffective against the insect pest on their fields and as a result, insect pest were not killed several days after spraying. This could build resistance of insects under field conditions as Abudulai et al. (2006) reported that applying ineffective and sub-lethal doses of insecticides induce resistance in insect pest on the field. This argument is also supported by Vassal et al. (1997) and Martin et al. (2000; 2002) findings that the cotton bollworm, *H. armigera* acquired resistance to *pyrethroids* in field populations in Cote d'Ivoire due to application of ineffective and sub-lethal doses of insecticides on cotton farms.

3.3. Pattern of insecticides usage

The results also showed that farmers in the area often apply insecticides very frequently. It was quite common 88 percent, for farmers to spray insecticides more than three (3) times on a cotton farm in a season (Table 3). The spray frequency in the area was as high as five (5) times in a season, confirming Abudulai et al. (2006) report that majority of cotton farmers in the Northern and Upper West regions sprayed five (5) times in a season. Most 83 percent farmers often sprayed their cotton farms in the first round at the vegetative stage (between 35-40 days) whiles only 17 percent of farmers indicated that the first round of spraying was done at the beginning of square formation (between 46-50 days). Though the farmers indicated that the first round of spraying was to control insect pest that will disturb flower bugs formation, this was contrary to findings by Greene et al. (2001) that applying insecticides at the vegetative stage is generally unnecessary as damage at this stage often does not result in economic yield reduction. The pattern of spray practiced by farmers in the Municipality could unnecessarily build up cost of production and drastic reduction in the population of natural enemies of insect pest as observed by Salifu (1990); Javid et al. (1998) and Greene et al. (2001).

Table 3. Pattern of insecticides usage

Type of insecticide	**Rounds of Spraying (%)**				
	1st	**2nd**	**3rd**	**4th**	**5th**
Lambda Cyhalothrin	-	-	74	-	-
Chlorpyriphos+ cypermethrin+Acetamiprid	-	-	-	72	61
Cyhalothrin	4	92	-	-	-
Chlorpyrifos	83	-	-	-	-
Profenos + Cypermethrin	-	-	21	-	-
Flubendiamide + Spirotetramate	13	8	-	-	-
Beta-Cyfluthrin+Imidacloprid	-	-	-	16	9
Percentage of farmers in each round of spraying	**100**	**100**	**95**	**88**	**70**

Source: Field Survey Data, January, 2013

3.4. Attitude of cotton farmers in handling pesticides

3.4.1. Selection and Storage practices

The study further revealed that majority 67 percent of farmers in the Municipality placed priority on availability rather than the correct and appropriate choice of insecticides type for their cotton fields. Similar attitude also led to most of the farmers using surplus products on food crops other than cotton without paying attention to the label, insofar as it is effective. The perception of cotton farmers on the choice of pesticide is driven by cotton companies who supply insecticides to farmers on credit and therefore dictate the type of insecticides used by cotton farmers. The results showed (Table 4) that majority of cotton farmers 67 percent, exhibited negative attitude in the storage of pesticides. It was found that farmers either stored their insecticides under their beds, kitchen or on top of trees on their farms without any warning signs or lock. This could exposed children and innocent adults or passersby to the harmful effects of the pesticides.

3.4.2. Usage practices

Similarly, with regards to usage practices cotton farmers in the Municipality exhibited high negative attitude 81 percent, in strictly observing usage information guide on the pesticide label which direct farmers to the best usage practices (Table 4). An inspection of empty pesticides cans revealed that some of the safety usage information on the labels as spelt out by manufacturers of the various insecticides included, wearing clean protective cloths, not eating, drinking or smoking whiles applying insecticides, not to allow insecticides to contact your skin, wash hands with detergents before eating, wash clothes with soap after each spray, not to stir insecticides with hand and never spray directly into the wind.

Table 4. Attitude of farmers in handling insecticides

Pesticide handling practices	Farmers response	Percentages (%)
Selection of Insecticides	Positive	16
	Negative	67
	Average	17
	Total	**100**
Storage of Insecticides	Positive	0
	Negative	90
	Average	4
	Not Applicable	6
	Total	**100**
Usage of Insecticides	Positive	4
	Negative	81
	Average	15
	Total	**100**
Disposal of Insecticides (Empty containers and tank washings)	Positive	0
	Negative	85
	Average	15
	Total	**100**

Source: Field Survey Data, January, 2013

However, when compared with on-farm usage practices by farmers it revealed that majority 80percent of the farmers were spraying insecticides without any form of protection, not washing their hands and cloths with any detergents after spraying and sometimes smoking or chewing cola nuts whiles spraying. This could exposed farmers to pesticides poisoning through inhalation, ingestion or skin contact as reported by (Yeboah et al., 2004; Mensah et al., 2004; Ajayi and Akinnifesi, 2007; Mekonnen and Agonafir, 2002; Yassin et al., 2002). The study further revealed that 41percent of farmers claimed they changed their clothes before and after pesticide use, however, less than 5percent washed these clothing before using them again. These contaminated clothing could enhance dermal exposure which could result in systemic poisoning.

3.4.3. Disposal practices

Furthermore, majority 85percent of cotton farmers claimed knowledge of disposal of empty insecticides containers and other pesticide related waste, but what was described and practiced by farmers were not appropriate for disposal of empty pesticide containers and other pesticide related waste. These farmers were found using empty insecticides containers to fetch water, store salt and sugar. Others were found leaving empty containers on their fields and washing of spray equipment close to water bodies. This could serves as source of pollution to both surface and underground water sources. This finding confirms earlier report by FAO (1999) that people often reuse empty plastic or metal pesticide containers as storage for fuel or even food and water, even though it is usually impossible to remove all traces of chemicals from these containers.

The study further established from close examination of user manuals of some insecticides used by the farmers (Tihan and Thunder) that pesticide manufacturers recommend that after application, empty containers should be rinsed at least three times before disposal. Also the user manuals indicated that empty containers should not be thrown into ponds and or rivers but be destroyed and buried. These recommended practices by the manufacturers were contrary to the FAO (1999) guidelines on disposal of pesticide containers that empty pesticide containers should not be buried or burned. The FAO noted that safe, hazard-free burning techniques required a good understanding of pesticide chemistry while safe pesticide burial requires knowledge of local hydrology as well as of the environmental behaviour of insecticides, which many end users do not have given their circumstances.

3.5. Pesticide residue level in drinking water sources closed to cotton fields

The *Organophosphates* and *Pyrethroids* pesticide residues were detected at higher concentrations in some of the water samples analyzed. About 54percent of water samples analyzed recorded mean concentration of insecticides higher than the GSA maximum residual limits of 0.5µg/L and the European Economic Commission (EEC directive 98/83/EC) allowable residual limits in drinking water at 0.1µg/L. *Cyhalothrin* was detected in water samples from all the four zones with western and northern zones (WZ=1.74µg/L and NZ=1.70µg/L) being the first and second highest respectively and exceeded the GSA maximum limits of 0.5µg/L. Similar observation was made for *Cypermethrin*, *Acetameprid, Flubendiamide, Profenos, Beta-cyfluthrin, Imidacloprid and Chlorpyrifos* (Table 5). However, while no traces of *Beta-cyfluthrin* was detected in the water sample of eastern zone (EZ) that of the water samples of NZ and WZ contained insignificant traces of *Acetameprid* and *Flubendiamide* which were far below both GSA and European Economic Commission (EEC directive 98/83/EC) allowable residual limits in drinking water.

Table 5. Zonal average insecticides residue level in drinking water sources

Zonal Water Samples	Cyhalothrin	Cypermethrin	Acetamiprid	Flubendiamide	Profenos	Beta-cyfluthrin	Imidacloprid	Chlorpyrifos
NZ	1.70*	0.37^	0.08	0.70*	0.34^	0.42^	0.77*	2.11*
EZ	0.47^	0.48^	0.23^	0.62*	1.08*	ND	0.70*	0.97*
WZ	1.74*	0.56*	0.24^	0.07	0.46^	0.30^	0.40^	0.43^
SZ	1.15*	0.26^	0.35^	0.50*	1.10*	0.58*	0.77*	1.67*

Source: Field Survey Data, January, 2013

NZ=northern zone, EZ=eastern zone, WZ=western zone, and SZ=southern zone; ND=not detected

** ≥0.5µg/L Ghana Standard Authority maximum residual limits for drinking water*

^ ≥0.1µg/L European Community allowable residual limits in drinking water

4. Conclusion

The study concluded that most water bodies of cotton growing areas in the Municipality are significantly polluted with insecticides residues, particularly C*yhalothrin*. Though different types of insecticides are used by cotton farmers to control insect pest of cotton in the Municipality *Pyrethroids* and *Organophosphates* are dominant. Some of the insecticides have the same active ingredients but they are traded under different names leading to multiple applications of such insecticides. Finally, cotton farmers in the Municipality demonstrate high level of negative attitudes in the handling of insecticides which could trigger serious health problems in future.

5. Recommendations

The study recommended that farmers should switch to the use of indigenous pest management strategies which are largely based on botanicals such as neem extracts which have been reported by researchers to be effective, less harmful to humans and economical in controlling major pest of cotton. Also, Government should give regulatory approval and promote the production of Bt cotton among famers to reduce the amount of insecticides used by farmers to control insect pest of cotton. This will also cut down the cost of production for cotton farmers in the country.

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