Schools Proximity to Plantations de Haut Penja, Learners’ Attitudes and Incidence of Pesticide Contamination in Cameroon

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Schools Proximity to *Plantations de Haut Penja*, Learners' Attitudes and Incidence of Pesticide Contamination in Cameroon

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Abstract

Learners at school can be subjected to pesticide exposures both from use in the schools and from nearby operations. *Plantations de Haut Penja* (PHP) is an agro-industrial plantation that uses pesticides to spray its bananas (*Musa spp*) using helicopters. This aerial spray couple with air drift of noxious particles exposes learners in nearby schools to acute and chronic effects. This paper sought to compare learners' attitudes with regards to pesticide, in schools located closer to, and further away from the PHP as well as the incidence of contamination among the latter. Data was collected from 600 learners across 10 secondary schools in two subdivisions. Analysis was done with Microsoft Excel 2016 and Statistical Package for Social Sciences (SPSS) 16.0 software. Findings depicted that schools are located 5m away from the PHP where pesticides are used on a daily basis. Hence, this exposes learners to the harmful effects of these chemicals. Wind was perceived as the main driver of pesticides drift into schools as it blows from the south west direction at a maximum speed of $30ms^{-1}$ which facilitates the drifting of airborne particles of pesticides. As a result, learners closer to the PHP are more vulnerable than their counterparts further away. Kruskal–Wallis test depicted that learners are also involved in pesticides related activities due to a plethora of reasons which further broadens the incidence of contamination among the latter. The study concludes that an environmental impact assessment be carried out in order to install wind barriers in the PHP to prevent spray drifts from entering into schools and that, the Ministry of Agriculture and Rural Development (MINADER) with its decentralized units, should ensure strict implementation of the legal framework on pesticide use and the development, application and evaluation of government policy in the domain of agriculture and environmental surveillance for the proper management of pesticides in Cameroon.

Keywords: Pesticide, proximity, contamination, learners' attitude, PHP, Cameroon

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1. Introduction

From the early 1990s till present, there have been many concerns about children's exposure and potential health risks related to pesticides around the world (US EPA, 2007). Therefore, the risks of exposure by human population from minor environmental contamination, however, largely go unnoticed. This is due to a dealt in literature on the relationship between residential and schools proximity to agricultural areas where Plant Protection Products (PPP) are used and children's exposure within these agricultural holdings. These PPP are seen as chemical substances whose active ingredients are capable of killing or destroying, repelling pests and diseases on plants as well as regulating plants growth (FAO & WHO, 2014). Therefore, these active ingredients are grouped under diverse chemical groups, some of which are more or less toxic than others and are capable of reacting with the body metabolism and causing harm.

Scholars have stressed on the correlation between pesticides and school-aged children or school going population (Curwin et al. 2007; Morgan, 2012) and hold the idea that, people who live closer to agricultural holdings are likely to be affected than people who live in non-agricultural zones. Other authors see school going population as a potentially vulnerable population to the harmful effects of PPP through a plethora of factors or drivers such as proximity to sprayed farmlands, learner's age, gender and take home pesticides by parents or household heads (Lu et al. 2000; Petchuay et al. 2006; Curwin et al. 2007; Panuwet et al. 2009; Morgan, 2012; Rohitrattana, 2014; Nkemleke & Kuété, 2020). Environmental factors are also responsible for pesticides drift to undesired areas. These factor among others are; the weather conditions at the time of application (i.e. wind speed and direction, temperature, relative humidity, and stability of air at the application site), methods of application, type of equipment, techniques used and spray characteristics (Miller, 1993; Miller & Smith, 1997; Ghosh & Hunt, 1998; Miller & Butler, 2000; De Jong et al. 2000; Womac et al. 2000; Van de Zande et al. 2003; Gil & Sinfort, 2005; Nuyttens et al. 2007; Yi, 2008; Baetens et al. 2009; Hanna & Schaefer, 2014; Graeme, 2017; Balsari et al. 2019; Baio et al. 2019; Desmarteau et al. 2019).

In agricultural holdings where pesticides are used on a daily basis, people may be affected through inhaling residues from drift and volatilisation. Other incidences of contaminations are triggered by dermal contacts and ingestion during pesticides application or in the long run, from residues that ooze into soils, accumulates in crops, or seep to groundwater (Brody et al. 2002). Similarly, Muir et al. 2004 have stressed on the ease with which some pesticides compounds undergo short-range atmospheric volatilisation to ecological regions. This is why other findings depict that in studies pertaining to exposure assessment process for quantifying pesticide exposures, it is imperative to define the population under survey, characterise temporal variation in patterns of pesticide use, determine the source of exposure (rate and method of application), and identify possible exposure pathways (residential proximity to the chemical hazards).

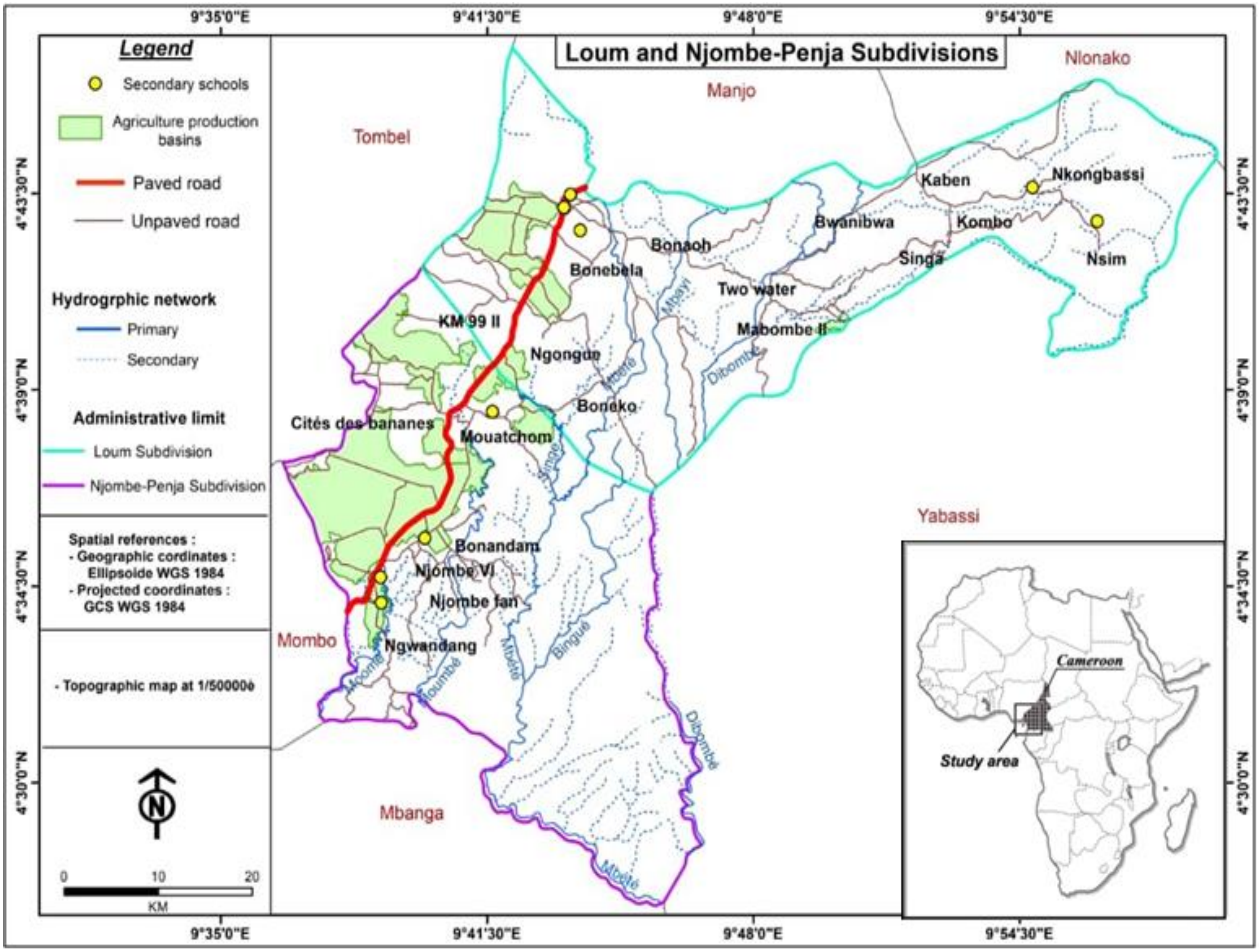
Pesticide poisoning and/or incidence of pesticides contamination has been a major health concern in Cameroon. Unfortunately, this problem has not been well documented, due principally to inadequate information and the poor understanding of its implications. The PHP, being an agro-industrial banana plantation in Cameroon, grows banana on the rich volcanic soils of the coastal lowlands of Cameroon mainly for export. As one of its primordial goals is to increase output, this plantation uses large quantities of pesticides on its bananas. Pesticides application is done on daily bases to spray bananas with the use of helicopters through aerial application. However, spray drifts from these banana estates get into residential areas and/or school yards which are located within 5 to 100m from these plantations; thereby exposing the entire population to the harmful effects of these pesticides. School going population (students) who live closer to the PHP and those who attend school located closer to these banana estates are no exception.

It is worth stressing at this juncture that the problem posed in this research is somewhat state-of-the-art because as most research findings have focused on the health related issues of PPP on farmers and other users, this study looks at the potential exposure and/or contamination of a neutral population (school going population) to these PPP. Thus, the main objective of this present research was to show that apart from farmers who use pesticides on a daily basis, school going population especially those living closer to agricultural holdings are more vulnerable to the harmful effects of pesticides use in these holdings. Hence, the study sought to attain the following objectives: to identify schools located closer to and further away from the PHP banana estates; to assess learners' attitudes/practices vis-à-vis some pesticides related activities closer to and further away from the PHP; and to identify the age group more likely exposed to PPP among school going population and the resultant effects of these toxic chemicals on them. This study also hypothesizes that school going population is potentially exposed to the noxious effects of PPP use in nearby agro-plantations.

2. Materials and Methods

2.1. Study site

The Mungo Division in the Littoral Region of Cameroon is where the study was conducted (Fig 1). This division is situated between 4°30'N and 4°43'N of latitudes, and 9°35'E and 9°54'E of longitudes. The Mungo Division is separated from the western highlands of Cameroon at the lower course of the river Mungo where the division got its name. This division stretches and occupies a south-north direction over a distance of approximately 140km (latitude 4° to 5° N).



Source: National Institute of Cartography 2018 and field work. Drawn by: Ernest Nkemleke

Fig 1: Map showing Loum and Njombe-Penja in the Mungo Division

The rainfall amount in this area stands >2000mm but shows some significant variability (augmentation) which is witnessed in Njombe (2700mm of rainfall) and in Penja (3000mm of rainfall), (Nkemleke & Kuété, 2020). The rainy season begins from March extending right to October. The dry season on its part, lasts only three months (October to January) and it is more observed in the north than the south of the Mungo Division. The temperature is between 22ºC and 24ºC in the Southern and Northern parts of the Mungo Division respectively. This study was conducted in the three major settlements of Loum, Penja, and Njombe in the Mungo Division.

2.2. Sampling

Diverse sampling procedures were used in this research. At the first phase, the study site was chosen due principally to the fact that school going youths are more and more engaged into pesticides related farming activities and this exposes them to the negative effects of these chemicals because of their limited knowledge, training in pesticides use and proximity of schools to agro-industrial banana plantations. At the second place, the study area was divided into two strata and stratified random sampling was used wherein, schools going youths were selected based on the proximity of their schools to agro-industrial plantations. The schools under survey were GBHS Manengwassa, GBHS Penja, GBHS Njombe, GSS Babong, SAR/SM Badjokip, Collège des Arts et Métiers (CAMEL), Lycée Technique de Loum, TISSERINS, CETIC de Njombe-Penja and Collège Polyvalent (Table 1).

Ultimately, the last phase involved interviews with key informants like heads of institutions and health personnel and other resource persons to ascertain the authenticity of the responses sourced from learners during surveys with questionnaires. Through questionnaires, 600 learners from ten (10) government and private secondary schools were interviewed with a 100% respondents' rate.

Table 1: Selected schools and geographic coordinates with sampled learners

School	Latitude	Longitude	Altitude	Learners sampled
GBHS Manengwassa	4°43' N	9°43' E	345 metres above sea level—masl	60
CAMEL	4°43' N	9°44' E	359 masl	60
Lycée Technique Loum	4°42' N	9°43' E	368 masl	55
SAR/SM Badjokip	4°42' N	9°58' E	335 masl	45
GSS Babong	4°43' N	9°55' E	350 masl	40
TISSERINS	4°34' N	9°35' E	289 masl	60
GBHS Penja	4°38' N	9°41' E	235 masl	30
CETIC de Njombe	4°36' N	9°40' E	278 masl	65
GBHS Njombe	4°35' N	9°40' E	340 masl	135
Collège Polyvalent Penja	4°38' N	9°41' E	260 masl	50

Source: Field work, 2019

2.3. Data Collection and Analysis

Both primary and secondary data were used for the study. Primary data was collected from 600 students in ten (10) schools. This was done through the administering of questionnaire to learners in the selected schools. The questionnaire was to obtain information pertaining to learners' socio-demographic parameters, and their attitudes/practices vis-à-vis pesticides. The survey was beefed-up with interviews conducted with health personnel, heads of various institutions, learners and other resource persons; and direct field observations.

Statistical analysis of data was done on SPSS 16.0 and Microsoft Excel 2016 using descriptive and inferential statistics techniques. Descriptive statistics used were percentage indices, charts, mean and standard deviation while inferential statistics was the Kruskal–Wallis (H-test). The mean and standard deviation was used to show how learners' attitudes and behaviours vis-à-vis pesticides differ across different schools.

The Kruskal–Wallis test was run to test whether there was a significant variation in the reasons for learners' involvement in pesticides related activities across sampled schools. This H-Test has also been used in a similar survey to show variations when dealing with reasons affecting people's choices (Nkemleke & Kuété, 2020).

The buffer zone was set at 1km. This is the maximum distance from the PHP to schools. This means that aerial spray of pesticides within this zone exposes the entire population to its harmful effects. Other studies have equally considered buffer zones for pesticides spray from source areas to susceptible areas within 1 to 4km (Frost & Ware, 1970; Chester & Ward, 1984; Hurley et al. 2014).

2.4. Variables used in the study

This study made use of some dependent and independent variables (Table 2). These variables are learner's age, incidence of pesticide contamination, category of pesticides, gender, suffer from pesticides effects, live in proximity to PHP, spray during dry/windy weather conditions, training in pesticides use, and interpret pesticides pictograms before use among others.

Table 2: Variables used in the study

Variable	Description
Learner's age	Continuous variable
Category of pesticides use	Continuous variable
Incidence of pesticide contamination	Continuous variable
Suffer from pesticides effects	Dummy variable, takes the value of 1 if yes and, 0 if no
Gender of respondents	Dummy variable, takes the value of 1 if male and, 0 if female
Live in proximity to PHP	Dummy variable, takes the value of 1 if yes and, 0 if no
Spray during dry/windy weather conditions	Dummy variable, takes the value of 1 if yes and, 0 if no
Interpret pesticides pictograms before use	Dummy variable, takes the value of 1 if yes and, 0 if no
Receive training in pesticides use	Dummy variable, takes the value of 1 if yes and, 0 if no
Use individual protection clothing	Dummy variable, takes the value of 1 if yes and, 0 if no
Eat while spraying pesticides	Dummy variable, takes the value of 1 if yes and, 0 if no
Clean up after using pesticides	Dummy variable, takes the value of 1 if yes and, 0 if no
Drink while spraying pesticides	Dummy variable, takes the value of 1 if yes and, 0 if no
Effects of take home pesticides	Dummy variable, takes the value of 1 if yes and, 0 if no
Medical attention when affected	Dummy variable, takes the value of 1 if yes and, 0 if no
Harvest on treated farmland after spraying	Dummy variable, takes the value of 1 if yes and, 0 if no

Source: Field work, 2019

3. Results and Discussion

3.1. Socio-demographics of learners

The socio-demographics of the learners sampled are expressed statistically as gender, age, level of education and/or class, resident, and school. Learners were sampled in ten (10) schools. The first school among the ten was a government bilingual high school (60 learners sampled), school two was a private high school (60 learners sampled), school three was a government technical school (55 learners sampled) and school four was a government college (45 learners sampled), school five was a private college (60 learners sampled), school six was a government high school (30 learners sampled), school seven was a government college (65 learners sampled), school eight was a government college (40 learners sampled), school nine was a government high school (135 learners sampled) and school ten was a private college (50 learners sampled), (Table 3).

Table 3: Socio-demographics of learners sampled

Characteristics		Frequency	%
Gender			
	Male	415	69.2
	Female	185	30.8
	Total	**600**	**100**
Class			
	Form 5	98	16.4
	Lower Sixth	233	38.8
	Upper Sixth	269	44.8
	Total	**600**	**100**
Age			
	10-15 Years	12	2
	15-20 Years	251	41.8
	20-25 Years	285	47.5
	25-30 Years	52	8.7
	Total	**600**	**100**
Reside near sprayed farms			
	Yes	390	65
	No	210	35
	Total	**600**	**100**
Type of learning institution			
	Government school	430	71.7
	Private school	170	28.3
	Total	**600**	**100**

Source: Field work, 2019

3.2. Most used pesticides in the study area

Small and large-scale farming activities in the study area use a variety of pesticides; some of which are not homologated or are banned products. For example, chlordecone[2] said to have been banned for use worldwide, have been reportedly used by the PHP on its bananas[3]. Some of these banned chemicals used are the cause of many acute and chronic health problems perceived in the study area. Although insecticides, herbicides and fungicides are the different types of pesticides widely used, it should be noted that there are sub groups which equally have different names (Table 4).

[2] Chlordecone is prohibited in Cameroon by decree No. 2011/2581/PM of August 23, 2011 Bearing regulation of harmful and/or dangerous chemicals

[3] Interview conducted by Transparency International Cameroon with the local population. Created by the American army, chlordecone is a pesticide made from very toxic chlorine, and suspected of being behind many cases of cancers.

Table 4: Most used pesticides

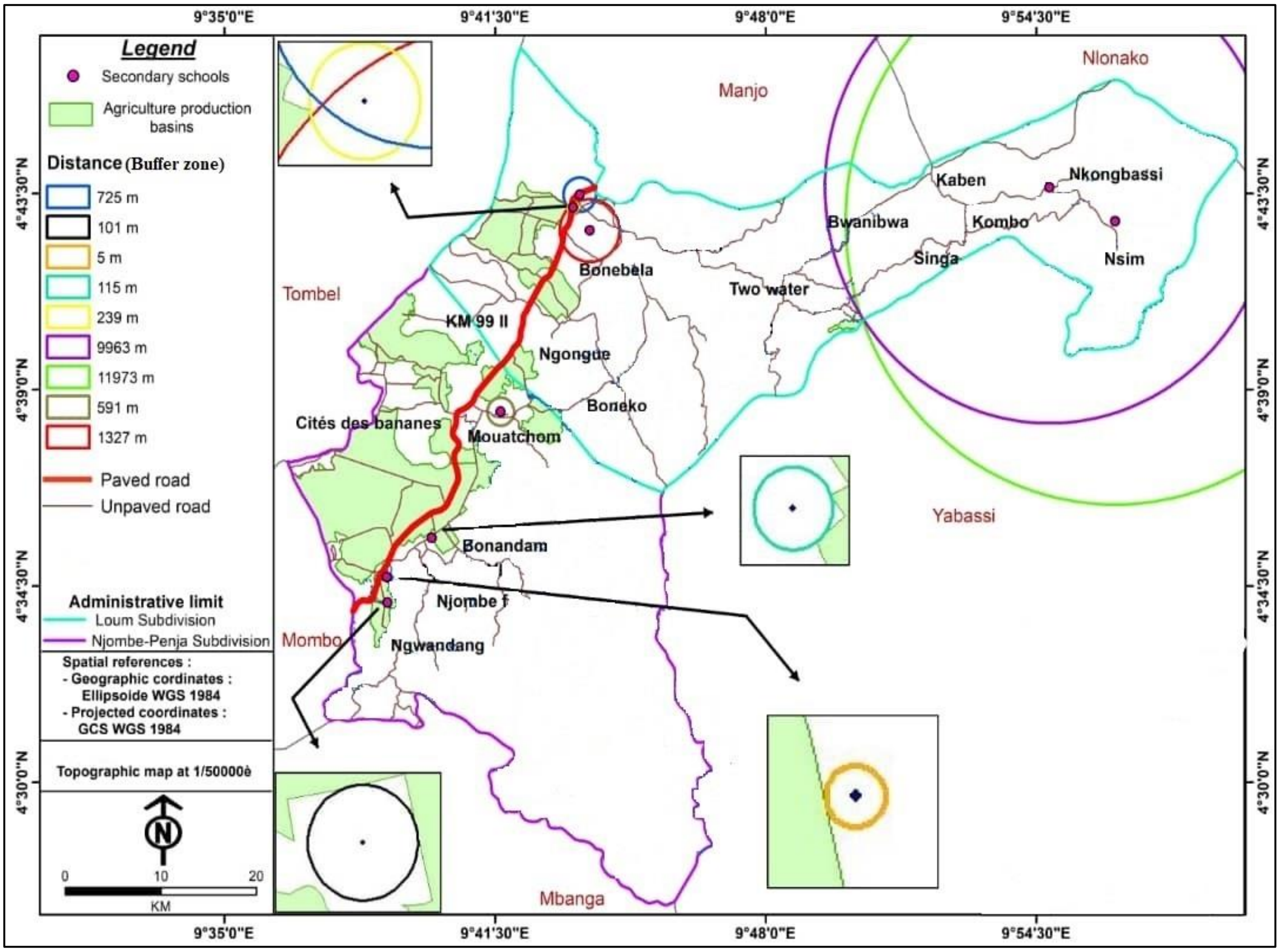
Pesticide	Product name	Toxicity class	Active ingredient
Herbicides	Glyphader	III	Glyphosate
	Gramoxone		Paraquat 200g/l
	Supraxone		Paraquat 200g/l
	Roundup	II	Glyphosate
Insecticides	Pyriforce	II	Chlorpyriphos-ethyl 600g/l; EC
	Capsidor		Fipronil
	Imida	II	Imidaclopride
	Capt Fort 180 WP	II	Lamdacyphalothrine + acetamipride
	Chlordecone	II	
Fungicides	Ridomil	III	Metalaxyl-M

Source: Field work, 2019

3.3. Schools proximity to PHP

One of the major concerns about pesticides use in agriculture is the potential for these chemicals to drift onto non-source points (neighbouring farms, and more importantly, into residential areas or school yards where students learn, work, and play). Pesticides can drift for about 400 to 800 metres away from the spraying areas.

Findings revealed that majority of secondary schools are located within 700 meters from the PHP in Loum and Njombe-Penja Subdivisions. Some of the schools are sited within 100 metres from the PHP while others are located somewhat less than 100 meters (Fig 2). For example schools like CETIC de Njombe, Collège Polyvalent, GBHS Njombe, CAMEL, GBHS Penja, GBHS Manengwassa and TISSERINS are all within the buffer zone with corresponding distances of 5m, 80m, 115m, 239m, 591m, 725m, and 802m respectively. Learners in these schools are exposed to pesticides spray drift and more likely to be harmed by these chemicals than learners whose schools are further away from the PHP. Meanwhile on the contrary vein, only Lycée Technique de Loum, GSS Babong and SAR/SM Badjokip are situated out of the buffer zone with corresponding distances of 1.327km, 9.963km and 11.973km respectively and learners here are less exposed to pesticides spray drifts and are unlikely to be harmed.



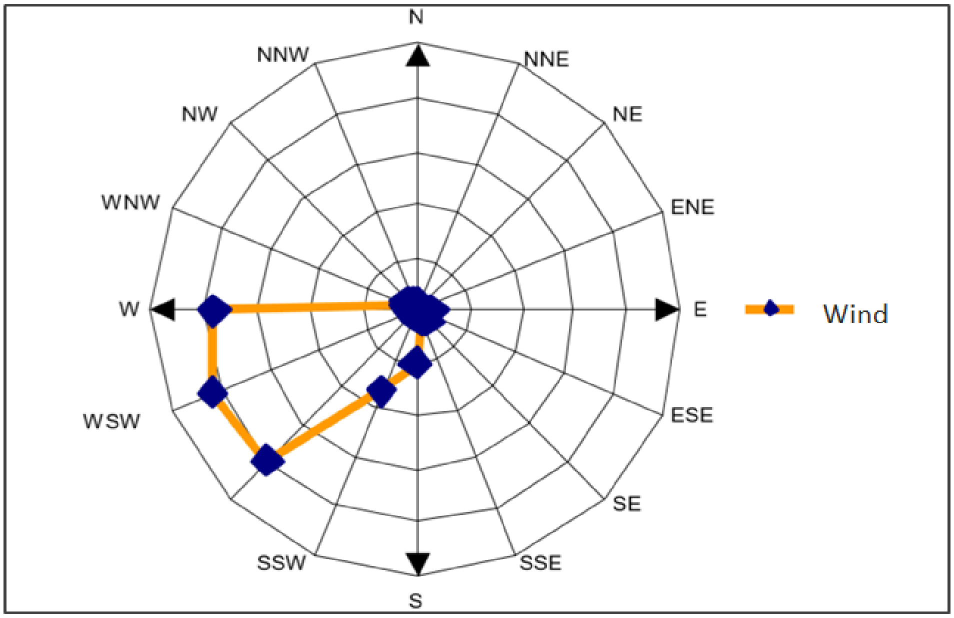
Source: National Institute of Cartography, 2018 and field work. Drawn by: Ernest Nkemleke

Fig 2: Proximity of schools to the PHP

This proximity of schools to the PHP exposes learners to pesticides infections borne by particles that drift from the PHP when aerial applications are done. Schools and/or residential proximity has equally been found to influence population exposure to agrichemicals by other studies (Ward et al. 2000; Lu et al. 2000; Fenske et al. 2000; Koch et al. 2002; Petchuay et al. 2006; Curwin et al., 2007; Panuwet et al. 2009; Morgan, 2012; Fenske et al. 2013; Hurley et al. 2014; and Rohitrattana, 2014; Nkemleke & Kuété, 2020). These findings depict that residential and schools proximity to agricultural holdings where pesticides are sprayed expose the population and learners to pesticides harmful effects. The above-cited research findings lent credibility to the present findings and therefore giving a new insight to existing discourses on residential proximity and pesticides effects.

3.4. Wind as the main driver of pesticides drift to schools

Wind is one of the most significant factors that influences spray drift. Wind direction and speed are indisputable drivers of particles drift. Through these, wind blows particles from one area to another across the air. This factor influences drift over and above every other factor. When the wind speed increases, there is also a drastic increase in drift and vice versa. The amount of pesticide lost from the target area and the distance it moves both increases as wind velocity increases. However, severe drift effects can equally take place in a low wind velocity, especially under situations of temperature inversion. This study found that wind direction and speed influence the drift of pesticides to schools and resident as the prevailing wind blows towards the direction of schools and residential areas (Fig 3).



Source: Modified from Feumba, 2015

Fig 3: Wind rose of Njombe-Penja with prevailing winds from WSW direction

In Njombe-Penja and Loum Subdivisions, which is the centre of pesticides use by the PHP through aerial sprays, the prevailing wind blows in the South West direction. This wind comes into the hinterland from Atlantic Ocean. The influence of a mountain barrier (Mount Cameroon) at the western side of the Cameroon range causes the wind to deflect to the right. These winds also correspond to the sea breezes that are felt as from midday, reaching their maximum at 2 p.m. and continuing until 8 p.m., then decreasing until 10 p.m. These winds turn into a light breeze that lasts till 8a.m. These winds from the SW can raise hoods of cars in the estuary, because they reach 0.25m in height and 4 to 5m in wavelength and move at the speed of $30ms^{-1}$. It is this wind which acts as the fastest means in drifting particles of pesticides in the air into off-target areas like school yards. The direction of the prevailing wind is WSW, (Fig 3). Schools proximity to the PHP means that particles are easily drifted from this plantation into inhabited areas. For example, Hanna & Schaefer (2014), Graeme (2017), Baio et al. (2019), Desmarteau et al. (2019) have confirmed that air is one of the main pathways through which pesticides reach undesirable targets. The current research findings corroborate the above mentioned findings, thus, making a new insight in the existing literature.

3.5. Learners' attitudes with regards to pesticides closer to and further away from the PHP

A comparative study between learners, who live and school closer to and those further away from the PHP, was conducted to determine learners' attitudes/practices vis-à-vis pesticides and proximity to agro-plantations.

3.5.1. Comparison between learners' attitudes/practices vis-à-vis pesticides in Loum

Learners, whose schools are further away from the PHP, were interviewed on some common pesticides related activities, (Table 5). Their responses were analysed with mean and standard deviation in order to determine the proportion of responses approving or disproving each claim.

Findings revealed that majority of learners in SAR/SM Badjokip which is located several kilometres away from the PHP do not live closer to sprayed farmlands ($\bar{x} = 1.00$), though, some of the learners use pesticides on their personal farms ($\bar{x} = 1.93$), learners do not play on the farm when pesticides are sprayed ($\bar{x} = 1.00$), but they witness symptoms of pesticides effects ($\bar{x} = 1.56$). Many household members witness the same symptoms ($\bar{x} = 1.56$), and the symptoms persist for a longer time before disappearing ($\bar{x} = 1.51$). Most learners eat during pesticides application ($\bar{x} = 1.56$), meanwhile others drink (alcohol in sachets, water) during pesticides application ($\bar{x} = 1.56$), (Table 5). All these broaden the rate of exposure to pesticides effects though; these learners live far away from the PHP.

In GSS Babong, learners live far off treated farmlands ($\bar{x} = 1.00$), but use pesticides on their own farms ($\bar{x} = 1.92$), play on the farm when small-scale application of pesticides is done ($\bar{x} = 1.42$), but do not witness pesticides effects ($\bar{x} = 1.12$). Most of them eat and drink when using pesticides with mean values of ($\bar{x} = 1.62$) and ($\bar{x} = 1.58$) respectively (Table 5).

In Lycée Technique (L.T) de Loum which is also located further away from the PHP, learners live far off sprayed fields ($\bar{x} = 1.00$), but most of them manipulate and/or use pesticides ($\bar{x} = 2.00$). Learners do not play on the farm when using pesticides ($\bar{x} = 1.00$), but they witness symptoms of pesticides effects ($\bar{x} = 1.94$). This could be as a result of contact via diverse means like transporting pesticides to the farm, mixing pesticides and spraying without individual protection kits. The same symptoms are also perceived on two or three other household members who manipulate pesticides ($\bar{x} = 1.62$), and the symptoms persist for a long duration ($\bar{x} = 1.60$) showing the severity of its effects. These symptoms could be due to the fact that most of them eat ($\bar{x} = 1.60$) and drink ($\bar{x} = 1.60$) during application of pesticides which further expose them to the harmful effects of these chemicals, (Table 5).

These findings prove that although learners in these schools live far away from sprayed farmlands (PHP), they also witness symptoms of pesticides effects. This is due to personal efforts from learners in attempts to alleviate poverty as they are involved in the manipulation of pesticides on their farms which makes them more vulnerable.

Meanwhile GBHS Manengwassa and CAMEL are the only sampled schools located close to PHP (Table 5). Findings among learners in GBHS Manengwassa revealed without contradiction that learners live closer to sprayed farmlands ($\bar{x} = 1.75$) and use pesticides ($\bar{x} = 1.82$). Also, most learners play around when pesticides are sprayed and they witness symptoms of pesticides effects with mean values of ($\bar{x} = 1.32$) and ($\bar{x} = 1.80$) respectively. With other household members infected by same symptoms ($\bar{x} = 1.58$), these symptoms persist for a long time before they disappear ($\bar{x} = 1.55$), sometimes after medical intervention for those who seek medical attention. Most of these learners eat ($\bar{x} = 1.38$) and drink ($\bar{x} = 1.50$) during pesticides application, (Table 5).

In CAMEL, learners live closer to PHP ($\bar{x} = 1.52$) and use pesticides on their farms ($\bar{x} = 2.00$). They do not play around when pesticides are sprayed ($\bar{x} = 1.30$) but all witness symptoms of pesticides effects ($\bar{x} = 1.80$). This is because majority of these learners attend school located few meters from the PHP where aerial applications are made. This increases the degree of exposure to pesticides residues drifted to school yards. It should be recalled that these symptoms are always witnessed on at least two or more household members ($\bar{x} = 1.58$) which show the extent to which the population is vulnerable. Learners here do not eat while spraying pesticides but do drink during this activity ($\bar{x} = 1.37$), (Table 5).

Following this analysis, learners who attend schools closer to PHP are more vulnerable to pesticides effects than the ones further away from this PHP. In this same vein, learners who are further away are equally affected by pesticides but this is due to contact during on-farm activities where pesticides are used in a smaller scale or quantities. This implies that those who are further away from the PHP are less vulnerable and consequently less affected by pesticides.

Table 5: Learners' pesticides related activities in schools closer to and further away from the PHP in Loum Subdivision

	Schools located in proximity to the PHP						Schools located further away from the PHP								
	GBHS Manengwassa n=60			CAMEL n=60			L.T de Loum n=55			GSS Babong n=40			SAR/SM Badjokip n=45		
Activities	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*
1. Live closer to sprayed farms	1.75	.439	Accepted	1.52	.504	Accepted	1.00	.504	Rejected	1.00	.000	Rejected	1.00	.252	Rejected
2. Use pesticides personally	1.82	.390	Accepted	2.00	.000	Accepted	2.00	.000	Accepted	1.92	.267	Accepted	1.93	.506	Accepted
3. Play around when pesticides are sprayed	1.32	.469	Accepted	1.30	.462	Rejected	1.00	.000	Rejected	1.42	.501	Accepted	1.00	.000	Rejected
4. Witness pesticide health symptoms	1.80	.403	Accepted	1.80	.403	Accepted	1.92	.267	Accepted	1.12	.335	Rejected	1.56	.503	Accepted
5. Same symptoms perceived by a family member	1.58	.497	Accepted	1.58	.497	Accepted	1.62	.490	Accepted	1.15	.362	Rejected	1.56	.503	Accepted
6. Symptoms persist	1.55	.502	Accepted	1.50	.504	Accepted	1.60	.496	Accepted	1.12	.335	Rejected	1.51	.506	Accepted
7. Eat during pesticides spray	1.38	.490	Accepted	1.30	.462	Rejected	1.60	.496	Accepted	1.62	.490	Accepted	1.51	.506	Accepted
8. Drink during pesticides spray	1.50	.504	Accepted	1.37	.486	Accepted	1.60	.496	Accepted	1.58	.501	Accepted	1.51	.506	Accepted

Source: Calculations based on field data, 2019.

N.B: M= Mean; St.D= Standard Deviation. GBHS Manengwassa and CAMEL *(Rejected ($\bar{x} \leq 1.3$), Accepted ($\bar{x} > 1.3$)). SAR/SM Badjokip *(Rejected ($\bar{x} \leq 1.23$), Accepted ($\bar{x} > 1.23$)). GSS Babong and L.T de Loum *(Rejected ($\bar{x} \leq 1.2$), Accepted ($\bar{x} > 1.2$))

3.5.2. Comparison between learners' attitudes/practices vis-à-vis pesticides in Njombe-Penja

Findings revealed that learners in GBHS Njombe live closer to the PHP ($\bar{x} = 1.68$), and some use pesticides on their farmlands ($\bar{x} = 1.72$). Thus, this shows the degree of vulnerability to pesticides. These learners do not play around ($\bar{x} = 1.43$) when pesticides are used yet they witness symptoms of pesticides effects ($\bar{x} = 1.79$). This shows that pesticides are drifted and deposited in school where learners get in contact with. Also, they eat ($\bar{x} = 1.78$) and drink ($\bar{x} = 1.86$) when aerial sprays of pesticides are done, (Table 6).

In TISSERINS, most learners do not live closer to the PHP ($\bar{x} = 1.52$) but use pesticides on their individual farmlands ($\bar{x} = 2.00$). They move around during aerial spray ($\bar{x} = 1.85$) and perceive symptoms of pesticides effects ($\bar{x} = 2.00$), although the same symptoms are not perceived by other learners ($\bar{x} = 1.55$). Learners in these school do not eat ($\bar{x} = 1.38$) during pesticides spray but they drink ($\bar{x} = 1.92$). With regards to GBHS Njombe, learners live closer to PHP ($\bar{x} = 1.67$) and use pesticides on their personal farms ($\bar{x} = 2.00$). They do not play around when aerial spraying is done, perceive no health symptoms, do not eat and drink during pesticides application with corresponding mean values of ($\bar{x} = 1.00$), ($\bar{x} = 1.60$), ($\bar{x} = 1.30$) and ($\bar{x} = 1.33$) respectively, (Table 6). This could be due to the fact that learners in this school are more cautious than their peers in other schools.

With regards to schools closer to the PHP (CETIC de Njombe and College Polyvalent), most learners live closer to PHP with respective mean values of ($\bar{x} = 1.54$) and ($\bar{x} = 1.58$). Also, in CETIC de Njombe, some learners use pesticides to spray crops ($\bar{x} = 1.80$) likewise in College Polyvalent ($\bar{x} = 1.96$). They also move around ($\bar{x} = 1.42$) when aerial sprays of pesticides by the PHP helicopter are done likewise in College Polyvalent ($\bar{x} = 1.38$). Learners are exposed to pesticides effects in these localities, yet in CETIC de Njombe they perceive no symptom of pesticides effects ($\bar{x} = 1.18$), but symptoms were reported among learners in College Polyvalent ($\bar{x} = 1.76$). These symptoms are rare among learners in CETIC de Njombe, though they always eat during pesticides spraying ($\bar{x} = 1.42$) but do not drink ($\bar{x} = 1.32$), (Table 6). Meanwhile in College Polyvalent, same symptoms were also perceived on other household members ($\bar{x} = 1.72$), but do not persist for a long duration ($\bar{x} = 1.76$). In this same light, learners do not eat when pesticides are sprayed ($\bar{x} = 1.02$), but they drink ($\bar{x} = 1.48$), (Table 6).

Following these results, it is noticed that almost all learners live closer to PHP in Njombe-Penja Subdivision. It is equally observed that, symptoms of pesticides health effects are common among learners who attend school closer to PHP than those who are further apart albeit not without symptoms. The symptoms reported among the latter are due to exposure during individual on-farm activities and the severity of these symptoms is not much as compare to those closer to the PHP where aerial sprays are done (approximately 50 sprays per month). This further increases the odds of being affected by pesticides.

Table 6: Learners' pesticides related activities in schools closer to and further away from PHP in Njombe-Penja

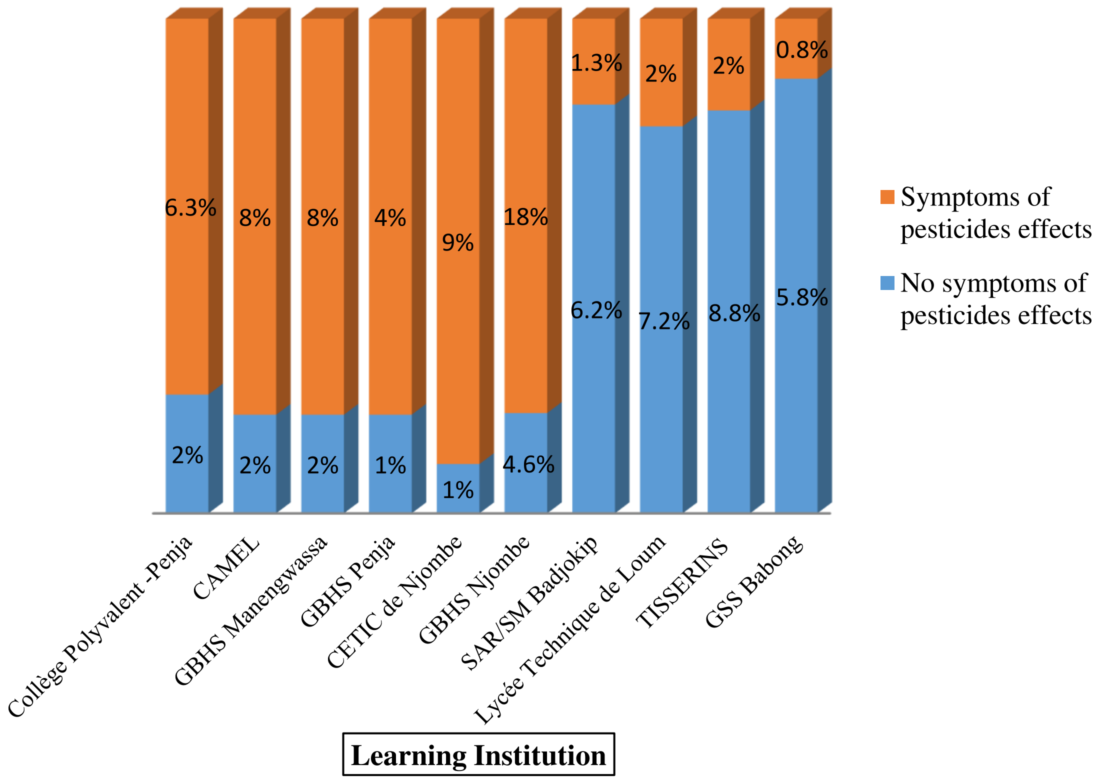
	School located in proximity to the PHP									School located further away from the PHP					
	GBHS Njombe n=135			TISSERINS n=60			GBHS Penja n=30			CETIC de Njombe-Penja n=65			Collège Polyvalent n=50		
Activities	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*	*M*	*St.D*	*Remark*
1. Live closer to sprayed farms	1.69	.496	Accepted	1.52	.504	Accepted	1.67	.479	Accepted	1.54	.502	Accepted	1.58	.499	Accepted
2. Use pesticides	1.72	.451	Accepted	2.00	.000	Accepted	2.00	.000	Accepted	1.80	.403	Accepted	1.96	.198	Accepted
3. Play around when pesticides are used	1.43	.497	Rejected	1.85	.360	Accepted	1.00	.000	Rejected	1.42	.497	Accepted	1.38	.490	Accepted
4. Witness pesticide health symptoms	1.79	.407	Accepted	2.00	.000	Accepted	1.60	.498	Accepted	1.18	.391	Rejected	1.76	.431	Accepted
5. Same symptoms perceived by a family member	1.14	.349	Rejected	1.55	.502	Accepted	1.40	.498	Accepted	1.15	.497	Rejected	1.72	.454	Accepted
6. Symptoms persist	1.86	.349	Accepted	1.93	.252	Accepted	1.27	.450	Accepted	1.57	.499	Accepted	1.76	.431	Accepted
7. Eat during pesticides spray	1.78	.417	Accepted	1.38	.490	Accepted	1.30	.466	Accepted	1.42	.497	Accepted	1.02	.141	Rejected
8. Drink during pesticides spray	1.86	.349	Accepted	1.92	.279	Accepted	1.33	.479	Accepted	1.32	.471	Rejected	1.48	.505	Accepted

Source: Calculations based on field data, 2018.

N.B: M= Mean; St.D= Standard Deviation. GBHS Njombe *(Rejected ($\bar{x} \leq$ 1.68), Accepted ($\bar{x}$ >1.68)). TISSERINS *(Rejected ($\bar{x} \leq$ 1.3), Accepted ($\bar{x}$ >1.3)). GBHS Penja *(Rejected ($\bar{x} \leq$ 1.15), Accepted ($\bar{x}$ >1.15)). CETIC de Njombe *(Rejected ($\bar{x} \leq$1.33), (Accepted ($\bar{x}$ >1.33)). Collège Polyvalent *(Rejected ($\bar{x} \leq$ 1.25), (Accepted ($\bar{x}$ >1.25)).

3.6. Symptoms of pesticide harmful effects among learners in various schools

Pesticides related health symptoms manifest on the body when someone is exposed to it. These health effects are short and long term. Some symptoms manifest within a shorter period of time, say within 24 hours after exposure while others take a longer time period to manifest. Students from all sampled schools who handle pesticides reported some symptoms within a time period of 24 hours while others reported symptoms few hours/days after spraying (Fig4).



Source: Field work, 2019

Fig. 4: Symptoms of pesticide harmful effects across schools

Fig. 4 clearly shows that learners in schools closer to the PHP witness pesticides related health effects than those in schools further away. Schools closer to the PHP like College Polyvalent, CAMEL, GBHS Manengwassa, GBHS Penja, TISSERINS and GBHS Njombe registered the highest number of health symptoms or effects with 6.3%, 8%, 8%, 4%, 10% and 18% respectively (Figure). Meanwhile schools further away from PHP registered fewer numbers of pesticides related health effects. SAR/SM Badjokip, Lycée Technique de Loum, CETIC de Njombe-Penja and GSS Babong are among this category with over 6%, 7%, 8% and 5% respectively. It should be noted here that students who show symptoms of pesticides effects in schools further away from the PHP get into contact with pesticides during on-farm activities.

3.7. Leaners' involvement in handling pesticides out of school

In ranking the reasons for learners' involvement in pesticides use out of school and to see if these reasons differ across sampled schools, the Kruskal–Wallis (H-test) was used (Table 7). Based on the Mean Ranks of the Kruskal–Wallis test it was found that among learners who are involved in pesticides related activities out of school, learners in Lycée Technique de Loum (mean rank =

391.97), GSS Babong (mean rank = 406.31), and Collège Polyvalent Penja (mean rank = 434.55) are involved in pesticides related activities because of a plethora of reasons (spraying their parents' farmlands, their personal farmlands, spraying for remuneration, own chemical shops, and transport or distribute pesticides) than their counterparts in GBHS Penja (mean rank = 283.80), GBHS Manengwassa (mean rank = 239.22), CAMEL (mean rank = 287.39), SAR/SM Badjokip (mean rank = 268.44), TISSERINS (mean rank = 189.27), CETIC de Njombe (mean rank = 271.68), and GBHS Njombe (mean rank = 293.00), who use pesticides only on their parents' farmlands (Table 7). In this same vein, the Kruskal–Wallis statistic indicated that there was a statistically significant difference among the reasons why learners are more involved in pesticides related activities across different schools (X^2 = 104.532, p<0.05). This further indicates that the reasons why learners carry out pesticides related activities vary significantly from one school to another.

Table 7: Ranking learners' reasons for using pesticide across school

School	Frequency (n)	%	Mean Rank	X^2	p-level
GBHS Manengwassa	60	10	239.22	104.532	0.000*
CAMEL	60	10	287.39		
Lycée Technique de Loum	55	9.2	391.97		
SAR/SM Badjokip	45	7.5	268.44		
TISSERINS Njombe	60	10	189.27		
GBHS Penja	30	5	283.80		
CETIC de Njombe	65	10.8	271.68		
GSS Babong	40	6.7	406.31		
GBHS Njombe	135	22.5	293.00		
Collège Polyvalent Penja	50	8.3	434.55		

*Significant at 0.05 probability level

3.8. Types of symptoms/illnesses among learners according to age group

A study conducted by Antle & Pingali (1994) depicts that "*scientific confirmed pesticide related acute illnesses are headaches, stomach pains, vomiting, skin rashes, respiratory problems, eye irritations, sneezing, seizures, and coma*". Similarly, according to the US EPA Office of Research and Development's Asthma Research Strategy, "*some pesticides have been linked to long term health problems, including: Cancer; asthma; leukemia; birth defects; endocrine disruption; neurological disorders and immune system deficiencies*".

The PHP is the highest user of pesticides in this area. These plantations carry out about 50 aerial sprays per month. Given that little or no effort has been done to minimise the environmental effects of these pesticides, residents closer to these plantation tend to bear the greatest brunt. Data sourced from health personnel show that pesticides related symptoms and illnesses are common among school going children (Table 8).

Findings revealed that pesticides related health symptoms and illnesses were common among youths aged between 20-25 years (143 cases) and between ages of 25-30 years (87 cases). Meanwhile these symptoms/illnesses were few among youth between the ages 10-15 and 15-20 (with 58 and 61 cases respectively) as compared to the former. This therefore, implies that older learners or students are exposed to agropesticides in this area than their younger counterparts.

Table 8: Types of pesticide related symptoms/illnesses amongst school-aged population

Age group	Illness/symptom	No. of cases
	Diarrhea	4
	Blurred double vision	8
	Testicular cancer	2
10-15 Years	Dry cough	8
	Bone cancer	5
	Bronchitis	5
	Abdominal pain/fever	26
Total		**58**
	Direct intoxication by chemicals	2
	Bilious	5
	Diarrhea	4
15-20 Years	Itches	2
	Respiratory problem	31
	Blurred double vision	13
	Bronchitis	4
Total		**61**
	Anorexia	6
	Leukemia	31
	Asthenia	13
20-25 Years	Memory loss	5
	Dry cough	9
	Diarrhea	6
	Blurred double vision	18
	Abdominal pain/fever	55
Total		**143**
	Leukemia	35
	Asthma	8
	Asthenia	12
25-30 Years	Severe anemia	10
	Abdominal pain/fever	6
	Respiratory problem	5
	Itches	1
	Diarrhea	10
Total		**87**

Source: District hospital Loum and Malt hospital Njombe, 2019

Other studies have equally reported the aforementioned symptoms and illnesses related to the use of pesticides (Maroni & Fait, 1993; Dich et al. 1997; Zahm et al. 1997; Kirkhorn & Schenker, 2002; Richter & Chlamtac, 2002 and Alavanja et al. 2004). It must be said that, these symptoms and illnesses were found on school going population who are only vulnerable to pesticides harmful effects; due to the fact that schools are located closer to agro-industrial plantations in the study area. However, other studies (Tetang & Foka, 2008; Manfo, 2010; Kenko et al. 2017 and

Pouokam et al. 2017) in Cameroon have found these same symptoms/illnesses among peasant farmers who use pesticides on a daily basis. Hence, making an insight that supports and lends credibility to this present research.

4. Conclusion and Recommendations

This study shows that school proximity to agro-industrial plantations exposes learners to the harmful effects of pesticides use in these nearby plantations. Schools are located within the buffer zone of aerial application of pesticides where particles are easily transported by wind to schools and residence. A comparative analysis shows that learners are more affected by pesticides in schools closer to the PHP than those further away. Moreover, learners' attitudes/practices towards some pesticides related activities show that some learners handle pesticides individually with little or no knowledge on the proper use which equally increases the risk of contamination. This is justified by some symptoms and illnesses common among these learners. Based on these findings, this study therefore, recommends the following: MINADER and other ministerial departments in charge of agriculture and environmental surveillance should carry out a thorough environmental impact assessment in the Mungo Corridor and provide wind barriers near the PHP to reduce spray drifts into school yards and residence; the PHP Group should sensitize the population on the danger of pesticides use in its plantations and consider meteorological parameters when aerial applications are done in order to reduce spray drift to undesired targets; and ultimately, smallholder farmers and learners who are involved in pesticides use should adopt safety measures to limit unnecessary contacts with pesticides and contaminations by these toxic chemicals.

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Authors' contributions
Efuetlancha Ernest Nkemleke as the first author performed the following tasks: conceptualization; data curation; methodology; analysis; writing the original draft; review and editing. Meanwhile Kuété Martin, the co-author did the supervision, conceptualization, review and editing.

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Consent to participate

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Consent to publish

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Figures

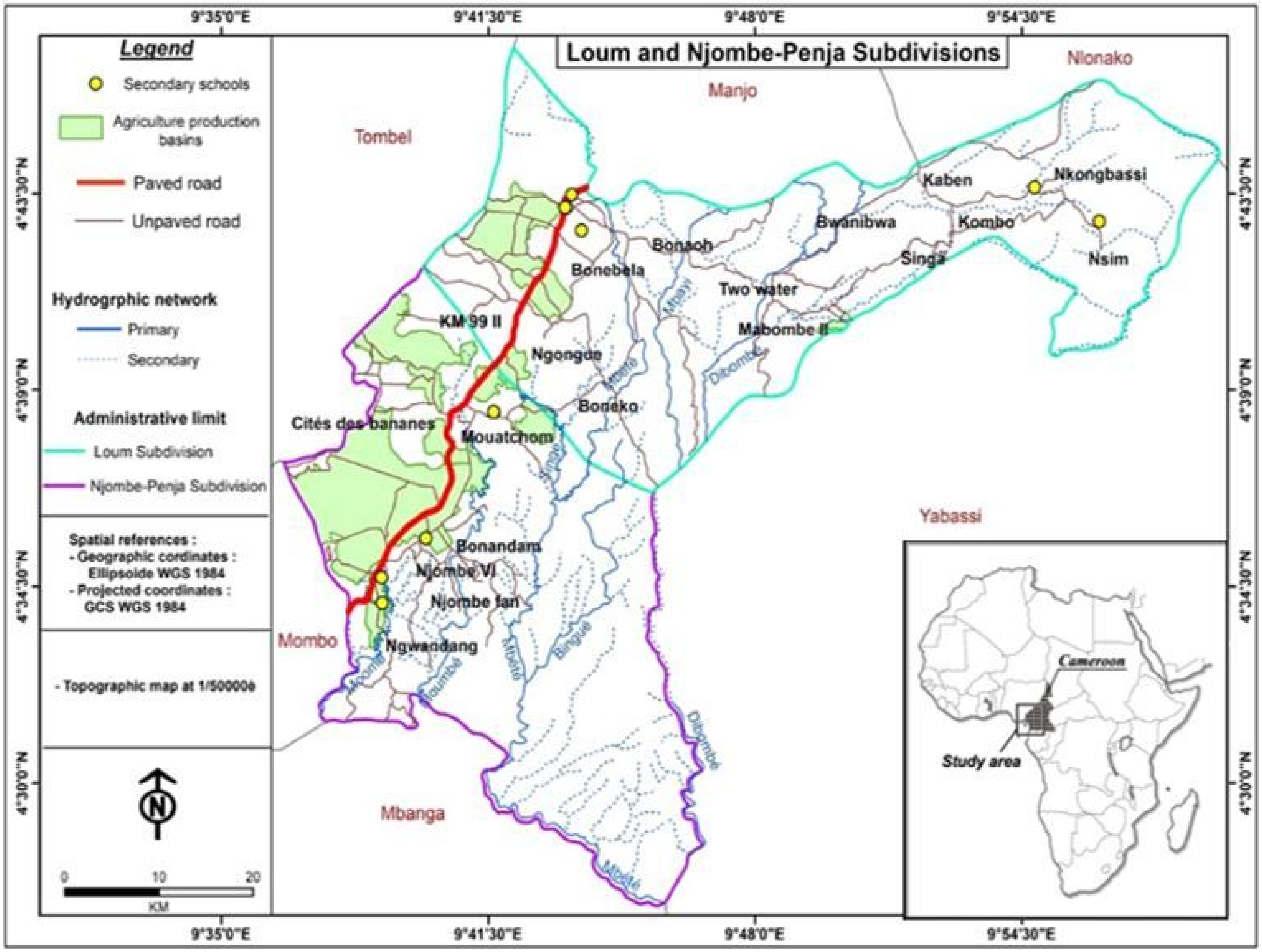

Figure 1

Map showing Loum and Njombe-Penja in the Mungo Division. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

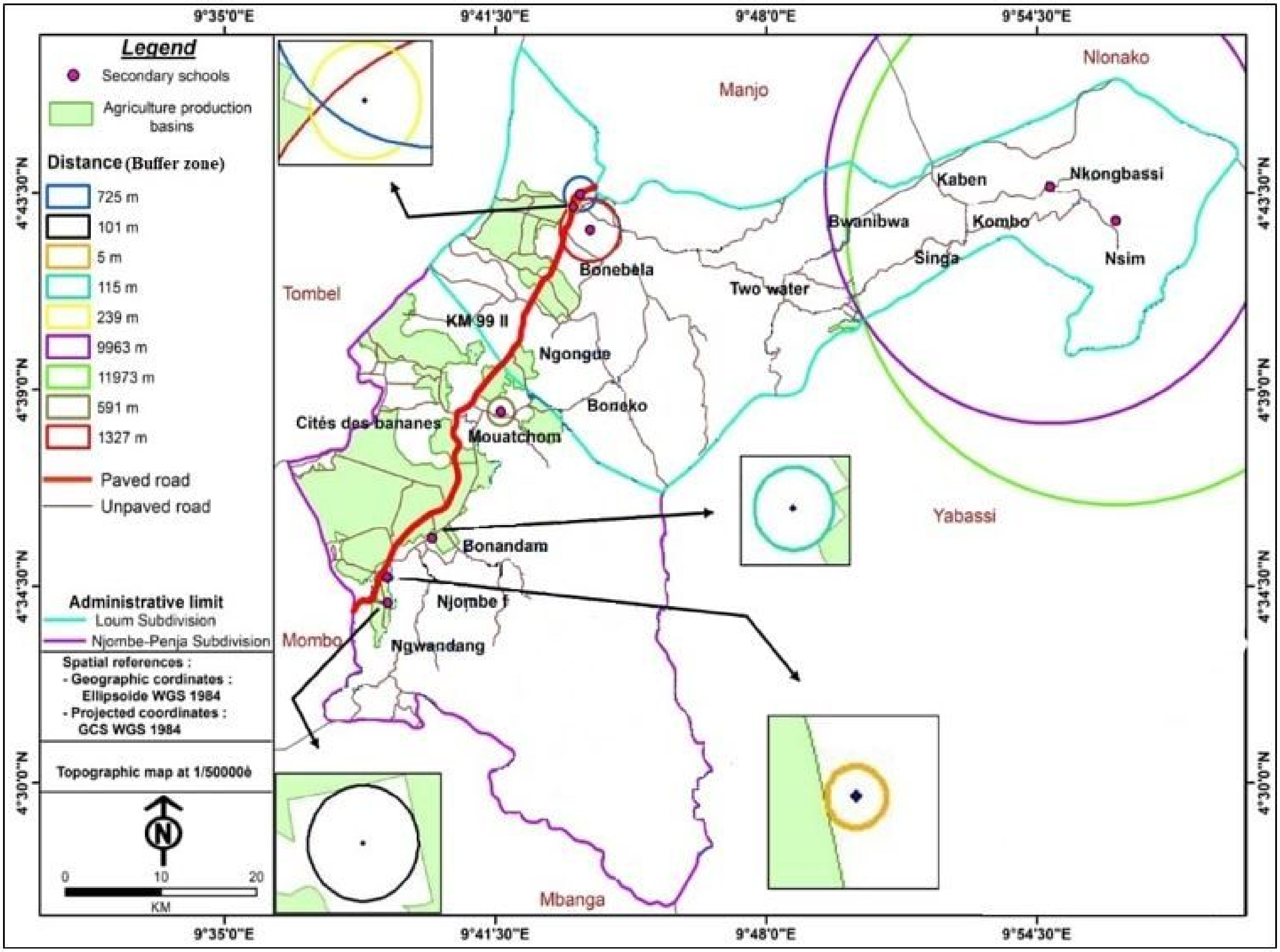

Figure 2

Proximity of schools to the PHP. Source: National Institute of Cartography, 2018 and field work. Drawn by: Ernest Nkemleke. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

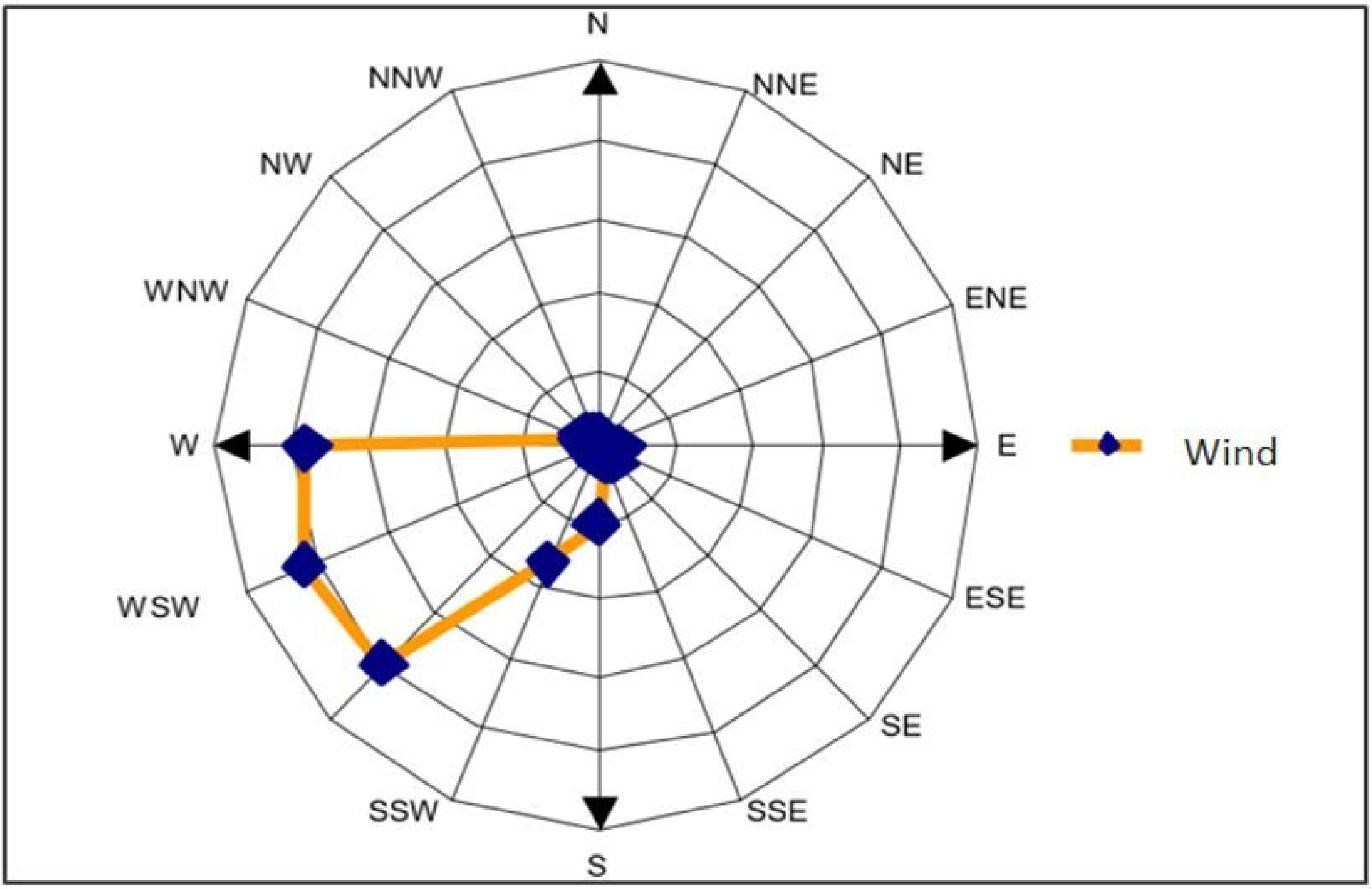

Figure 3

Wind rose of Njombe-Penja with prevailing winds from WSW direction. Source: Modified from Feumba, 2015

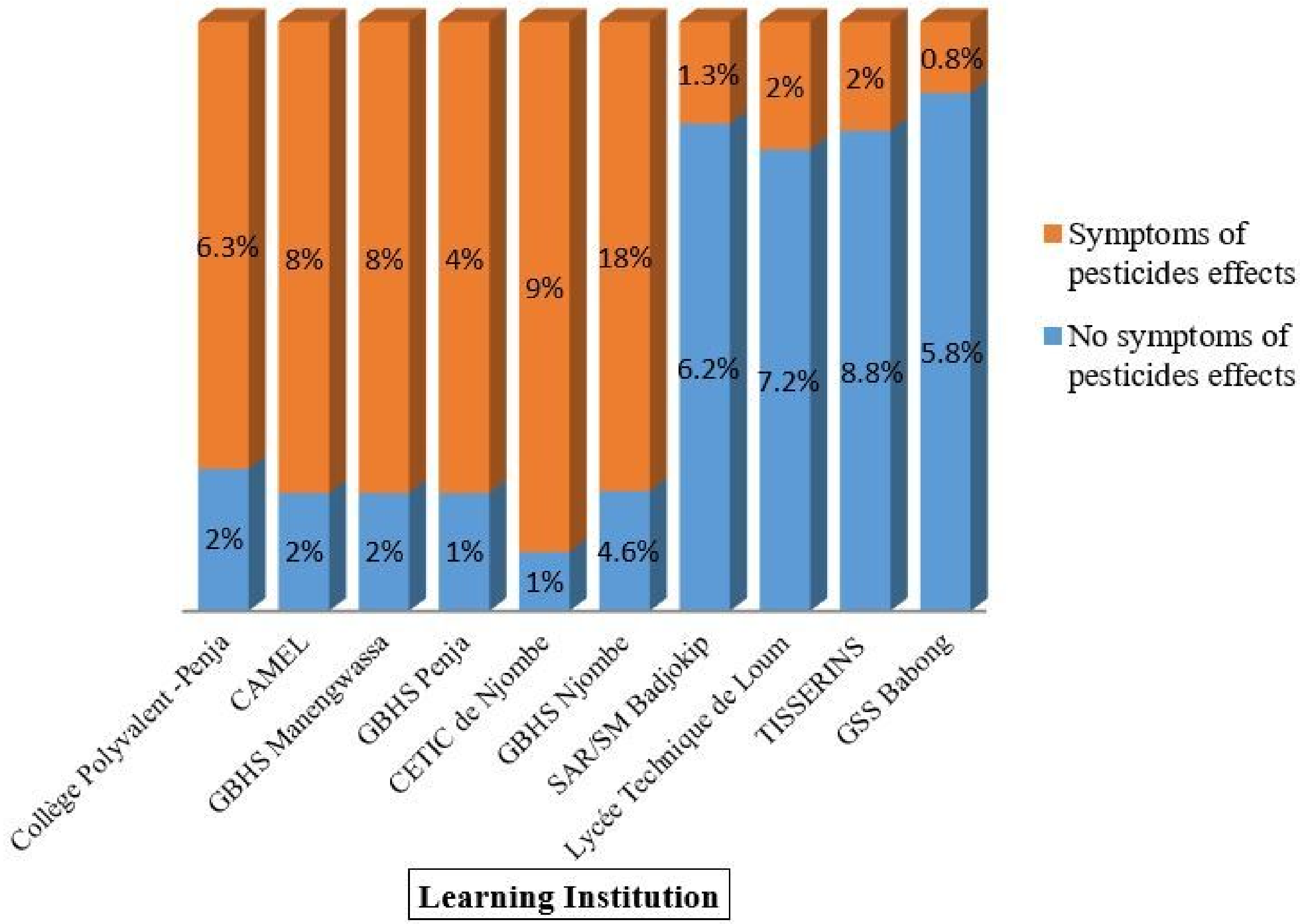

Figure 4

Symptoms of pesticide harmful effects across schools. Source: Field work, 2019