An assessment of the impacts of pesticide use on the environment and health of rice farmers in Sierra Leone

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Abstract

One of the biggest challenges faced by Sierra Leonean farmers is pest control. Birds, rodents, insects, crustaceans and other organisms can drastically reduce yields. In order to prevent these organisms from destroying their crop, farmers use pesticides. However there are reports that these chemicals are being misused and such misuse is having a negative impact on the environment and the health of the farmers.

This research study aimed to investigate the use of pesticides in rice fields and its potential effects on the environment and on the farmers of Sierra Leone. Five hundred farmers and one hundred health workers across the country were interviewed. Fifty focus group discussions were also completed. Field observations were also undertaken to see how farmers apply pesticides to their farms and the possible threats these methods have on human health and the environment. It is clear that a wide range of pesticides are used by rice farmers in Sierra Leone with 60% of the pesticides used entering the country illegally. Most farmers have no knowledge about the safe handling of pesticides as 71% of them have never received any form of training. The pesticides kill both target and non-target organisms some of which enter the food chain.

Cases of health problems such as nausea, respiratory disorders and blurred vision investigated in this research are significantly higher among farmers who use pesticides than those who do not use pesticides. Cases of pesticide intoxication are not investigated by health workers but results obtained from interviews with them also indicated that cases of pesticides related symptoms are significantly higher in environments where pesticides are used than those in which pesticides are not used.

Key words: Pesticides, environment, health

Introduction

1.1 Background

West Africa has 57% of Africa's rice cultivatable land (Oteng and Sant'Anna, 2015). However pests such as blast, rice stem borers, termites, birds, rodents and other organisms are negatively affecting rice production (Samado et al 2014; Gianessi; 2014; Oteng and Sant'Anna, 2015). Sierra Leone which is used as a case study in this research is a major rice producing country in West Africa. Agricultural practices in Sierra Leone are similar to other West African countries such as the Republic of Guinea, Liberia, Senegal, and Gambia. These countries face similar food production and pest control challenges (Samado et al 2014; The Guardian newspaper, 2015). Therefore issues affecting one country are likely to be applicable to others.

About 74% (5.4 million ha) of the land in Sierra Leone is considered arable but only <15% is currently being cropped (Asenso et al 2009; CARD, 2009; Sannoh, 2011). Sierra Leone has five major cultivable ecologies. These are upland (4.42 million ha), bolilands[1] (145,000 ha), riverine lowlands (130,000 ha), mangrove swamps (20,000 ha) and inland valley swamps (690,000 ha). The agriculture sector is the major employer in the country which is estimated at 70% of a population of about six million people (Sannoh, 2011).

Rice, being the major staple food of the country, is the most widely cultivated crop throughout Sierra Leone (Johnny et al 1981; Vellag, 2012). It is cultivated in all the five major cultivable ecologies. The consumption rate of rice at 104 kg annually per capita in Sierra Leone is among the highest in sub Saharan Africa (CARD, 2009; Vellag, 2012; Ighobor, 2014; World Bank 2014). The crop sub-sector contributes about 75% of the agricultural GDP of the country (CARD, 2009). Prior 1970, Sierra Leone was able to produce enough rice for internal consumption and even provide some exports to a limited extent (CARD 2009). The trend started to decline during the 1970s and, in the 1980s, Sierra Leone produced only 66% of the rice needed to feed the nation. One of the reasons for this decline in rice production was pest control. Subsequently Sierra Leone has become a major rice importer. The situation became worse during the 11 years of civil war (1991 -2002).

[1] Boliland; This is a seasonally swampy area associated with rivers

1.2 Pest control in Sierra Leone

As mentioned, one of the biggest challenges faced by Sierra Leonean farmers is pest control (IRIN 2007). Birds, rodents, insects, crustaceans and other living organisms including bacteria and fungi, can drastically reduce yields, in some cases between 40 to 50% (Cheng, 1990). To prevent these organisms from destroying their crops, farmers use pesticides. The use of these chemicals is controlled by the Ministry of Agriculture. However, there are reports that these chemicals are being misused and are supplied to illiterate farmers without any training on how to use them safely and effectively (USAID, 2009). They are often supplied by minor traders selling them in small unlabelled sachets. There is evidence that some pesticides are entering the country illicitly which farmers are using indiscriminately without the knowledge of the Ministry of Agriculture (Ministry of Agriculture, 2010). These include: “Yarifos” which contains chlorpyrifos-methyl ($C_7H_7Cl_3NO_3PS$) and an organophosphate which was not stated on the label, “Sarifos” which contains chlorpyrifos-ethyl ($C_9H_{11}Cl_3NO_3PS$), 2,4D [(2, 4-Dichlorophenoxy) acetic acid ($C_8H_6Cl_2O_3$)] and pentachlorophenol. (C_6Cl_5OH).

Insecticides can accumulate in the tissues of both flora and fauna in the ecosystem (USAID, 2009). After absorption, insecticides can be transported and magnified along the food chain. Insecticides can also accumulate in soil and sediments and are potentially transported to other areas within Sierra Leone and neighbouring countries by water and air. This might pose threats to other environments, which are far away from the point of contamination.

Human exposure to insecticides can result in a range of harmful effects with the extent of damage dependent on the type of insecticide and/or the level of intake. For example, exposure to organophosphates can result in the inhibition of the enzyme cholinesterase which can result in nervous disorders. Organophosphate exposure has been associated with headache, excessive salivation, lacrimation, nausea, diarrhoea, respiratory depression, seizure, loss of consciousness and pinpoint pupils (PSEP, 2015; Medline plus, 2015). According to Roberts and Reigart (2014), herbicides do not exhibit acute effects on humans and other animals with the most common effects being skin irritation, vomiting, diarrhoea, and nausea.

In order to address some of these issues this study investigates how pesticides are used in practice in rice fields in Sierra Leone and how these uses impact the health of rice farmers and the environment. In particular this study focussed on the prevalence of pesticide use among rice farmers in Sierra Leone, paying particular attention to the application methods to assess potential impacts and risks to human health and the environment.

Materials and Methods

2.1 Study area

Sierra Leone has four major land forms (the coastal lowlands, interior lowlands, the interior plateau and the Peninsula Mountains, see Figure 1). The lowlands are in the savannah grassland and the plateau is in the tropical rain forest. Sierra Leone has seven major rivers (the Sewa river, the great Scarcies, the little Scarcies, the Mano river, the river Rokel, the Moa river and the river Young (Figure 5)) that drain directly into the Atlantic ocean which borders the country from the north-west to the south-west (a coast line of 340 miles). These rivers are perennial and have many tributaries that drain into them. This network of rivers and tributaries often flood their plains providing most parts of the country with high levels of irrigation especially during the rainy season. As a result, the lowlands have a high potential for agricultural production.

Figure 1: Map of Sierra Leone showing rivers and districts

Sierra Leone experiences two major seasons. The rainy season runs from May through to October and the dry season runs from November to April. The average rainfall ranges from 4,000 mm in the west to 2,000 mm in the North. The average temperature ranges from 23 to 29^0C (National Geographic, 2015). The country also experiences South-East trade winds and North-West trade winds. The North-West trade winds are experienced from December through to February and bring about a micro season known as the Harmattan in the dry season. During this period, hot and dry winds from the Sahara desert blow across the country. This enhances the drying of crops and hence is the most common harvest time in the country especially for rice which is the most cultivated crop in the country (CARD, 2009).

2.2 Methods

Five hundred farmers were interviewed using a structured interview schedule (contained in Appendix 1). Structured questionnaires (contained in Appendix 2) were applied to 100 health workers. The interview schedule was designed in such a way that the resultant information obtained from the farmers could be analysed both qualitatively and quantitatively. Five hundred household head farmers were selected at random from a population of approximately 146,000 household head farmers. This sample size was calculated using the formula:

$$sample\ size\ (ss) = (z\text{^}2 \times p \times (1-p))/C\text{^}2$$

Where: z = 1.96 for 95% confidence level

p= percentage selecting a choice

C = confidence interval

The corrected infinite sample size (n) was calculated using the formula,

$$n = ss/(1 + (ss - 1)/pop)$$

Where pop = population size (http://www.surveysystem.com/ssformula.htm).

The sample size was also verified using chi-square tests with the aid of SPSS SamplePower software. The sample size was proportionately divided to each of the 12 districts in which rice cultivation is carried out. The proportion was calculated

based on the level of rice production (FAO, 2012; Leone Resources, 2015). The structured questionnaires targeted a total of 100 health workers in health centres within the selected production areas. However, the distribution of the health workers' respondents was not proportional as it was determined by the number available and those willing to participate.

Table 1: The distribution of respondents in the study area

Province	District	Chiefdom[2]	Town/village	Number of farmers interviewed	Number of health workers interviewed
Eastern Province	Kono	Soa	Kamadu	10	2
		Sando	Kayima	10	2
		Gbane-Kandor	Koardu	10	2
	Kailahun	Kpengewea	Bunumbu	15	2
	Kenema	Tonkia	Gorahun	15	1
Southern Province	Bonthe	Sogbani	Karleh	15	1
	Bo	Kakua	Sembehun 17	28	6
		Lugbo	Bontiwo	10	1
	Pujehun	Yekomo Kpukumu Krim	Boma	12	3
		Sowa	Geo Jagor	10	1
	Moyamba	Kargboro	Mokainsumana	20	2
		Kargboro	Lawana	12	1
		Bompeh	Moya	12	3
Northern Province	Bombali	Sella Limba	Kapethe	15	0
		Sandamagbolontho	Mayata	15	2
		Sanda Taindaren	Rogbin	20	2
	Tonkolili	Cholifa	Mathora	16	2
		Gbokorlenken	Patifu-Mayopoh	20	2
	Kambia	Samu	Kychom	45	15
		Mambolo	Mambolo	20	5
		Mambolo	Rokupr	20	5

[2] Chiefdom: This is a territory ruled be a paramount chief (the highest local head in the territory)

		Mambolo	Katima	20	2
	Port Loko	Lokomassama	Babarawallah	40	5
		Lokomassama	Kalangba	25	5
		Lokomassama	Gbentiwallah	25	3
		Kaffu Bullom	Conakrydee	10	5
	Koinadugu		Kabala	30	20

The schedule used for the interviews was translated into Krio (the most widely spoken language in Sierra Leone) and tested in a pre-survey using 10 farmers from Gbentiwallah. The tested questionnaire was adjusted and sent to the Statistics Department at Lancaster University for approval before the survey. The interviews were carried out by a team of six people, which included five trained field assistants, over a two month period. The questionnaires for health workers were distributed to health personnel and either collected the same day or a day after.

Focus group discussions were also held with target groups not covered by the interviews. The non-target groups were young farmers and women who support farming activities. Group sizes varied from 6 to 10 participants. The interview schedule was used to guide the discussions but not to limit the information to that required by the schedule. Communications were conducted mainly in Krio although two were in Themene, one in Susu, and one in Mende. The discussions were completely informal and for the young farmers conducted in the evening at "ataya"[3] bases where most young men and boys gather to enjoy their leisure time. The discussions with women especially house wives, were undertaken in the morning before starting their daily domestic work. A total of 10 focus group discussions were carried out for each group.

Discussions were also held with various stakeholders on the issue of pesticide use on rice fields including: a Parliamentarian who had a 0.61 km^2 rice farm and was a member of the Agriculture Oversight Committee in the Sierra Leone Parliament, a prominent member of the pest control unit at the Ministry of Agriculture, Forestry and Food security, an American environmental engineering expatriate and staff of two privately owned pest control units in Freetown.

[3] Ataya base: This is a ghetto like place built like a hut where a Chinese tea called 'ataya' is boiled and sold

Field observations were made on 20 farms to observe how farmers handled pesticides in the field. Five upland, five boliland, four inland valley swamps and six riverine farms were observed. Numbers were allocated to farmers who volunteered to have their farms visited. These numbers were balloted and selected numbers were chosen for field observation. The following activities were observed:

- Storage
- Handling
- Protection
- Preparation
- Application
- Surrounding activities (such as people working on the farm and adjacent farms, eating)
- Effects on pest and other life forms

Observations were noted in a field notebook, photographs were taken and the activities filmed.

2.3 Data analysis

The data was tested for normality using Shapiro Wilks normality test and normal Q-Q plots using SPSS. Since the results obtained proved that the data was not normally distributed, a Mann-Whitney test in SPSS for non-parametric data was used to compare the volume or mass of pesticide used on the farms of various sizes.

Data obtained from interviews were analysed using simple percentages, chi-squared (x^2) test and bar chats. Ordinal symmetric measures were carried out using Kendall's tau-b tests and directional measures were carried out using the Somers'd test.

To compare the health indicators captured by this research between farmers using pesticides and those not using pesticides, cross-tabulation and chi-squared (x^2) tests were used.

Results and discussion

Both quantitative and qualitative data are presented and discussed where appropriate within the main activities of the study. Out of 100 questionnaires distributed to health workers, 95 were eventually collected (numbers not collected from various regions are shown in parenthesis on Table 1). The results obtained represent 95% of the sample size.

3.1 Prevalence of pesticide use by rice farmers in Sierra Leone:

According to the FAO, (2011), 90% of the farmers in Sierra Leone are poor and can only undertake subsistence farming which does not provide them with sufficient funds to purchase pesticides. However the results obtained from interviews in this study indicate that 86.4% of respondents use at least one type of pesticide on their farms. This means the use of pesticides in rice cultivation is common in Sierra Leone. It has also been stated that 60 – 70% of the work force in Sierra Leone are farmers (FAO, 2014) and 80% of these are rice farmers (Encyclopaedia of Nations, 2014). Exposure to pesticides is not only limited to people considered to be within the working age range which is between 18 and 65 years. It was also observed that children as young as 8 years and farmers as old as 75 years are involved in farming activities which involves direct exposure to pesticides. Both male and female farmers are potentially exposed but from the focus group discussions it was revealed that mainly boys and men between 15 to 60 years handle and apply pesticides on the farms. This is an indication that most of the population in Sierra Leone comes into contact with pesticides which could lead to significant negative health effects if these substances are not handled properly.

3.2 Types of pesticides used in Sierra Leone rice fields

Results obtained from the interviews indicate that a wide range of pesticides are used by farmers in Sierra Leone. These include internationally banned pesticides in UK and USA such as parathion. However the most commonly used pesticides include chlopyrifos (60%), furadan (20%), malathion (5%), and carbolinium (5%). Herbicides like propanil and 2,4-D are in use but not very common. These pesticides are sold under different brand names such as “Sarifos”, “Yarifos”, “Tricel”. Pesticides such as these have been reported to exhibit a range of effects on both exposed people and the environment (Alcocer et al, 2000; Acker and Nogueira, 2012; Alves et al, 2012; Androutsopoulos et al, 2012; Ali et al, 2014; Mahamood et al, 2014; Bedi et

al 2015). This is an indication that the way pesticides are used in Sierra Leone can be hazardous to both the people exposed to pesticides and the environment.

Data from interviews suggested that both the volume of carbolinium and the mass of solid pesticides (furadan) used does not depend on the size of the farm (carbolinium: U=6.000, Z=-2.449, p=0.014; solid pesticides (furadan): U=7.000, Z=-1.273, p=0.0203). For the pesticides in solutions, such as chlorpyrifos, malathion and propanil, the volume of pesticide used depends on the size of the farms (U=10.5, Z=0.306, p=0.759). carbolinium and furadan are applied at various points within the farms and not necessarily the whole farm. Hence the size of the farm does not influence the quantity that is used. The pesticides in solution are mixed with the seeds and then broadcast[4]. The quantity of seeds used is proportional to the size of the farm and it is also directly proportional to the volume of pesticides required. Therefore the bigger the size of the farm the higher the volume of pesticide required. Interviews and field observation showed that the volume of pesticide in solution used per bushel (27 kg) of rice varies from farmer to farmer. Sixty one percent of the respondents who use these types of pesticides use 70 ml per bushel (27 kg) of rice, 15% used 35 ml per bushel, 11% use 140 ml per bushel and 9% use 105 ml per bushel. About 4% used between 200 ml to 500 ml of pesticide solution per bushel. The volume used depends on the purchasing power of the farmers and the size of the farm. There is no prescribed threshold to limit the use. Such practice can lead to over use and if this happens over a long period it may lead to chronic effects such as sex-selective alterations of serotonergic synaptic function in adults (Gevao et al, 2000; Aldrige et al, 2004).

Since the majority of rice farmers are poor, they cannot afford to buy pesticides from legal vendors. They usually end up purchasing from illegal vendors who sell them in small quantities. Those that are unable to pay in cash can take a loan and pay using their produce after harvest. The interview results show that 52% (260) of the respondents do not know the names of different pesticides and were unable to distinguish between the different types especially the liquid pesticides. Most of them depend on the illiterate vendors to explain it to them. These vendors depend on the pictures of the target pests on the original containers. If they obtained them from

[4] Broadcast: to scatter seeds on the field by hand

unlabelled containers, which is frequently the case, they can mislead their customers. It was observed that most of the pesticides are sold to the farmers in unlabelled containers such as used water bottles, fizzy drink bottles, alcohol bottles or sachets (Figure 2).

Figure 2: Containers in which most pesticides are sold

It was revealed from the focus group discussions that some of the vendors can deliberately or out of ignorance mislead customers by selling the wrong products to them. In Bo, a farmer said during the focus group discussions:

> *"I went to buy a pesticide to kill bedbugs in the house but what the lady selling the pesticides brought out and wanted to sell was propanil which is an herbicide. Even after telling the lady that it is not the correct one she argued that it is because that was what the agricultural extension worker from which she bought it said".*

To verify this story a small survey was carried out. An extension worker in charge of pesticide distribution was contacted to purchase chlorpyrifos which he said he had for sale. He brought out propanil and claimed that the two pesticides are the same. After buying the propanil from him, he was asked to bring chlorpyrifos in addition to propanil. He did not have chlorpyrifos but went to a local vendor to purchase some. This suggests that the extension worker, in this case, was familiar with pesticide

identification. This is an indication that illiterate farmers sometimes buy and sell the wrong products unknowingly.

3.3 Sources of pesticides

Results from the interviews also indicated that 46% of the pesticides used in Sierra Leone originate from packaging and processing factories in the Republic of Guinea from where they enter Sierra Leone illegally (Figure 3). They are brought into the country by illiterate small scale traders who do not understand the instructions written in French. Focus group discussions revealed that most of the limited supply of legitimate pesticides that comes from Freetown also end up in the hands of street vendors as in the case discussed above.

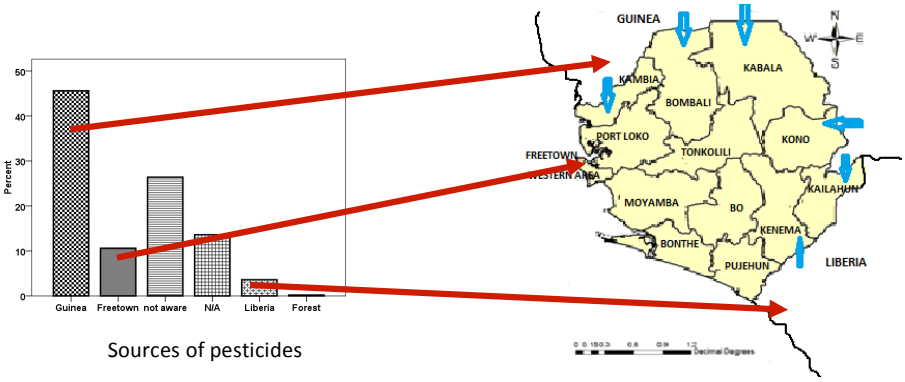

Figure 3: Supply routes for pesticides to and within Sierra Leone. The bar chart shows the percentage coming from various routes.

It appears that pesticides are being illegally importated into Sierra Leone and as this represents an uncontrolled use it requires regulation. However, based on interviews carried out in this study pest control stake holders are of the opinion that the scale of such illegal imports is low and therefore can be expected to have a minimal negative impact. These expectations have never been justified by any research evidence.

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The pest control units are supposed to regulate and monitor the use of pesticides. However, interviews and focus groups discussions showed that, instead of regulating and monitoring the use of the supplied pesticides, extension workers often sell the supplied stock to the street vendors who in turn sell them to the farmers.

It was found that 26.4% of the respondents did not know the source of the pesticides they use. They just go to the market and buy from petty traders. There is evidence that petty traders sometimes mislead their customers (the case of the farmer mentioned above). This means there is high risk of buying the wrong pesticides. From the focus group discussions, farmers said sometimes the pesticides they buy from petty traders have lost their 'power' so when they apply them they are not effective. This indicates that the farmers do not even know what they are buying. Any type of pesticide can be applied even if it is not suitable for the target pest.

3.4 Training and education

It was found that 71% of the respondents have never received any form of training on the safe use of pesticides. Only 17% received some form of training and 80% of these trained farmers received informal training from untrained farmers. As a result the application methods are haphazard and largely by trial and error. This is has important implications for both the environment and the health of the farmers.

However, there are groups of trained personnel present in major cities across the country. Some of these are attached to government pest control units and some to private pest control units. Most of these trained personnel are semi-illiterate youths who do not understand the complexity of pesticides. They are supplied with personal protective equipment although they are often not used as intended. During a discussion with two of these groups, it was discovered that these trained personnel do not apply pesticides on rice farms except those farms owned by government officials who could afford to hire them. They apply pesticides to homes and offices

most of the time. Even these trained personnel do not know the differences between some of the pesticides they use.

From the interviews, it was found that 56.4% of the farmers have no formal education (Figure 4a). Twenty three percent (primary and junior secondary levels) are not educated enough to understand instructions written on the labels. Only 20.6% of the respondents are considered to have adequate education to read and fully understand instructions written on the labels. However 90% of those considered having adequate education cannot read the instructions in French.

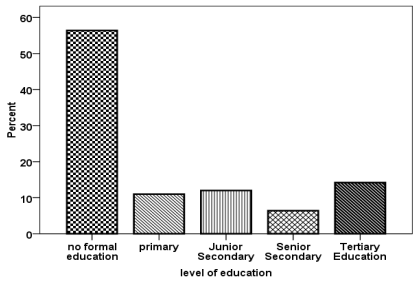

Figure 4a: Level of education of respondents

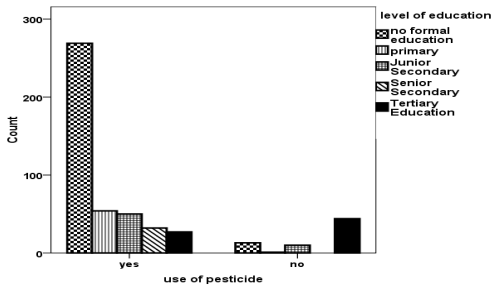

Figure 4b: cross tabulation bars showing the education levels of respondents that use pesticides and those that do not use pesticides

The educational categories represented in Figure 4a include both farmers that use pesticides and those that do not. When cross-tabulated and subjected to a chi-squared test, it was found that there is a significant difference in education levels between those who use pesticides and those that do not use them ($p = 4.35E-30.004$, $T = 7.243$ Kendall's tau-b SE = 0.042, Sommers'd SE = 0.37). It was observed that 62% (269) of farmers that use pesticides have no formal education whilst 64.7% (44) of those that do not use pesticides have tertiary education (Figure 4b). The perception of people with no formal education can be much more difficult to change than those with formal education (Ecobichon, 2001; Gaber and Abdel-latif, 2012). They tend to confine themselves to the first concept they learn. This means most of the farmers would be unlikely to accept new methods especially if they are

more laborious and involve a higher cost. Lack of training and education of farmers using pesticides could lead to the misuse of these chemicals and hence increase the risk harm to both the farmers and the environment.

3.5 Storage and handling, application and exposure

3.5.1 Storage

From the results of the interviews, it was revealed that rice farmers place pesticide containers in stores, holes dug close to their homesteads or houses, under the bed, in bedrooms (but not under the bed), roofs, on banana plantations, bush, farms, and toilets (Figure 5). Only 1.8% of respondents did not store pesticides. This group of respondents said they buy their pesticides the same day they intend to use them. Most of the respondents (26%) kept their pesticides in stores as recommended by the Ministry of Agriculture. However, it became apparent that the stores farmers talked about are not ideal for this function. The stores were also used for storing food, fire wood, farming equipment and kitchen utensils which could lead to accidental poisoning. The focus group discussions revealed that deaths have occurred as a result of poor storage. An incident that could serve as an example of accidental poisoning as a result of poor storage was reported by young farmers at Kychom during a focus group discussion. They said that a young man went into a friend's room when the owner was absent where he saw a bottle of alcohol under the bed. The bottle was in fact being used to store pesticides which he drank and died shortly afterwards. Cases of children drinking pesticides were also reported in other regions.

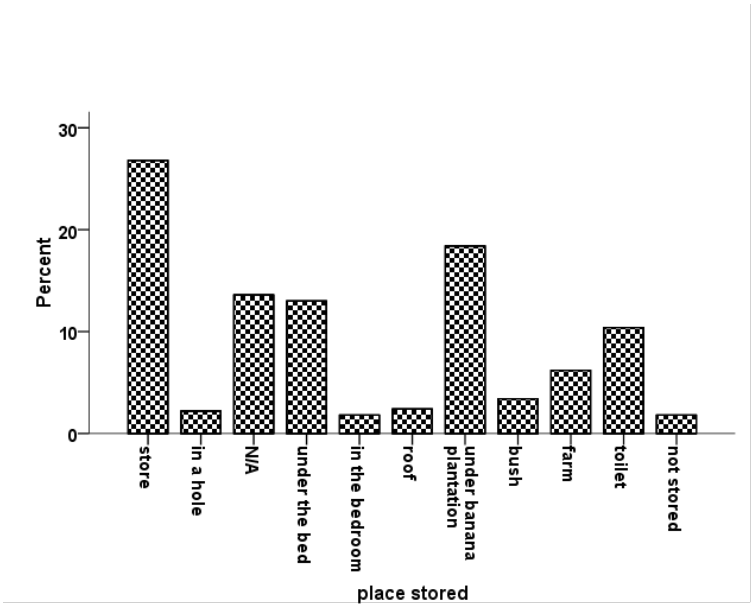

Figure 5: Places where pesticides are stored

3.5.2 Handling, application and possible exposure routes

From the results obtained during the interviews, 90% of farmers use no form of personal protection when applying pesticides. Three types of preparation were observed among farmers using liquid pesticides, with the exception of carbolinium. The first set mixed the pesticides with germinating seeds, diluted with an unquantified volume of water and then broadcast. The next set of farmers mixed the pesticides with rice husk, diluted with an unknown volume of water and then broadcast on the field before transplanting the seedling. The third set used sand instead of rice husk. In all cases the mixing was carried out without gloves or other forms of personal protection.

For furadan, the only solid pesticide observed, farmers parboiled a portion of the seeds with the pesticide to let the parboiled seeds absorb the pesticide and then broadcast the poisoned seeds on the farm. The process was repeated two or three days later before broadcasting the seeds that were not parboiled.

During application, 90% of farmers followed the wind direction to avoid inhaling the pesticides. During the focus group discussions it was reported that a farmer had

collapsed while he was applying a pesticide on his farm. Other farmers said it was because he was working against the wind. He was moved away from the farm to an open field and was given some palm oil to drink. He recovered after one hour. Other farmers working on the same farm or adjacent farms reported inhaling the pesticides during and after application but they believed they would not be affected after drinking palm oil. Focus group discussions and field observations revealed that farmers also eat on the field just after application of pesticides. They rub mud on their hands and then wash them with water before eating. This could be a possible route of exposure.

Another potential route of exposure is via the consumption of contaminated food or secondary poisoning. Focus group discussions revealed that some farmers eat organisms such as rodents and birds that have been killed directly following pesticide application. A young farmer in a focus group discussion said:

> *"If the pesticides kill organisms like cane rats, guinea-hen, and other animals, we eat them as long as the organisms are freshly killed. We just cut off the head, remove the internal organs and rub palm oil on it to remove the remaining poison".*

In some areas, the pesticides are used for hunting bush meat and fish. Cases of food poisoning were reported during a focus group discussion at Samalain in Pujehun district, south of Sierra Leone. In the Gallinese-peri chiefdom, it was observed that farmers wait around the farms after applying furadan to capture dying birds which could not fly as a result of poisoning but were not yet dead. These birds are cooked and eaten by the local population.

3.6 Environmental effects

From the interviews, all respondents using pesticides admitted that pesticides kill both target and non-target organisms. The non-target organisms mentioned were snakes, worms, insects, mud skippers, rats, and farm animals. From results obtained from interviews, 51% of the farmers who apply pesticides on their farms and have

462 farms on water bodies or close to water bodies said that the pesticides they use do
463 not kill fish. Only 5% accepted that they can kill fish as well. The rest were not
464 certain.

465 On boliland and inland valley swamp ecologies, the dead organisms observed after
466 the application of pesticides were insects, frogs, and worms. Other organisms like
467 bivalves were expected to die but were not observed. Furadan and carbolinium were
468 applied on upland farms during the field observations. Carbolinium was seen killing
469 termites but the effect of furadan was not seen. No dead organisms were seen after
470 the application of the pesticide during the two day visits to all of the upland farms. It
471 is possible that both target and non-target organisms were not present during that
472 period. Based on the findings, it is clear that application of pesticides have a
473 negative impact on biodiversity especially the fauna. According to the American
474 expatriate interviewed, pesticides used by farmers contaminate adjacent water
475 bodies. Some of these water bodies include those used for bathing and cooking.

476 **3.7 Health**

477 Among the health problems associated with exposure to pesticides, the following
478 cases were investigated: skin problems, nausea, seizure, respiratory disorder,
479 blurred vision, loss of appetite, lacrimation, nervous disorder, head ache and
480 stomach ache. All of these cases can be symptoms of pesticide exposure (CCOHS,
481 2010; Lah, 2011; Toxic Action Centre, 2012; EPA, 2014).

482

483 Results from the interviews indicate that cases of skin problems, nausea, seizure,
484 respiratory disorders, blurred vision, loss of appetite, lacrimation and nervous
485 disorder were significantly higher among farmers who use pesticides than those who
486 do not ($p<0.05$,). There is no significant difference between farmers suffering from
487 head ache and stomach ache using pesticides and those not using pesticides
488 ($p>0.5$,). A similar trend was also observed from the results obtained from the health
489 workers although the number of patients with skin problems, nausea, seizure,
490 respiratory disorders, blurred vision, loss of appetite, lacrimation and nervous
491 disorder that go to the hospital per week is low when compared to the total number

of patients that report to the various health centres (>80% between 0 and 10 for all the cases).

This indicates that the use of pesticides maybe having a negative impact on the health of farmers. Importantly, none of the health workers questioned indicated that health issues connected to pesticide poisoning were being investigated. All symptoms were being treated as malaria, typhoid or other diseases not related to pesticide exposure. The few chemical intoxication problems reported (10%) are related to caustic soda (used to make soap) and herbal medicine overdose.

Farmers believe in treating pesticide intoxication with palm oil. They also attempt to remove the contamination present in organisms killed by pesticides using palm oil. This treatment is not based on any scientific proof or evidence. However, looking at the nature of palm oil as an effective organic solvent, it is possible that non polar organic pesticides could be absorbed by the solvent phase, hence making it less poisonous. This has yet to be demonstrated.

Another traditional practice reported during the interviews and observed during the farm visits was the rubbing of mud on the hands after the application of pesticides before eating. This practice is also not based on any scientific evidence. However, it is known that pesticides like chlopyrifos have high affinity for soil where it binds strongly (Gebremariam et al, 2012; Álvarez et al 2013). It is therefore possible that rubbing mud on their hands would remove the pesticide residues. However, this practice still remains a possible exposure route.

Cases of pesticide intoxication appear to be significantly higher among farmers using pesticides than those not using pesticides. This can only be a pointer, not an absolute health indicator.

4.0 Conclusion

The use of pesticides in Sierra Leone is considered to be very low by various stakeholders but this research has shown that it is not the case. The majority of rice farmers are using pesticides. It has been shown that a range of current use pesticides are in widespread use by rice farmers. Most of the pesticide formulations are smuggled into the country in an uncontrolled manner. They can be easily

obtained in small quantities which even the poorest farmer can afford. Hence the prevalence of pesticide use in Sierra Leone is high.

Results from the interviews indicate that pesticide application has a negative impact on biodiversity as they affect both target and non-target organisms. In Sierra Leone where the use of pesticides is largely uncontrolled, the exposure concentrations at which this occurs is high. The methods of application are likely to lead to the pollution of adjacent water bodies and their continuous use is likely to result in accumulation in soil and sediments, some of which could be transported to other areas by erosion especially during the rainy season when the adjacent water bodies flood their plains. Comparing these findings to previous research, there is an indication that the uncontrolled use of pesticides is likely to be having negative effects on the environment (van der Werf, 1996; Stark and Banks, 2003; Desneux et al, 2007; van Dyk and Pletschke, 2011; Pingali and Roger, 2012).

The storage, handling, preparation and application methods have also been shown to be inappropriate resulting in unacceptable human exposure. Food and other materials are also likely to become contaminated during storage. The majority of farmers handle pesticides without any personal protective equipment and hence exposure is likely to be considerable. During the application process, farmers often inhale the pesticides resulting exposure to respiratory systems. Another possible route of exposure is via the organisms that farmers collect from these environments and used as source of food (i.e, secondary poisoning). These organisms are likely to contain residues of pesticides absorbed from their environments.

Exposure to pesticides has been associated with a range of negative human health outcomes (CCOHS, 2010; Lah, 2011; Toxic Action Centre, 2012; EPA, 2014). Given the range of potential exposure routes, it is likely that rice farmers in Sierra Leone may suffer from health problems related to pesticide exposure. This is demonstrated by the results from health workers' interviews and farmers' interviews. As a result of the lack of monitoring of health effects, it is difficult to determine if farmers are experiencing the chronic effects of pesticide poisoning (CCOHS, 2010).

5.0 Recommendations

The following recommendations are made:

- The Sierra Leone Government should improve regulation and control the import of pesticides into the country and illegal importation should be minimized if not stopped.
- Pesticides must be handled by trained personnel and should not be sold openly in local markets by petty traders
- Farmers should be trained on how to handle, store and apply pesticides before been allowed to use them on their farms. The Sierra Leone government should team up with agriculture based institutions such a Njala University to train more personnel to train farmers on how to apply pesticides
- Health workers should routinely test for pesticide poisoning on patients. The Government and its development partners such as WHO, MSF should make sure that facilities required for testing for pesticide poisoning are provided in health centres.
- Manufacturers should use more pictures/photographs to demonstrate how to handle pesticides safely (Rother, 2008). No pesticide should be supplied in unlabelled containers

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