

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

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8 **Abstract**

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

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

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

30

31 **Key words: Pesticides, environment, health**

32

33

Introduction

34 1.1 Background

35 West Africa has 57% of Africa's rice cultivatable land (Oteng and Sant'Anna, 2015).
36 However pests such as blast, rice stem borers, termites, birds, rodents and other
37 organisms are negatively affecting rice production (Samado et al 2014; Gianessi;
38 2014; Oteng and Sant'Anna, 2015). Sierra Leone which is used as a case study in
39 this research is a major rice producing country in West Africa. Agricultural practices
40 in Sierra Leone are similar to other West African countries such as the Republic of
41 Guinea, Liberia, Senegal, and Gambia. These countries face similar food production
42 and pest control challenges (Samado et al 2014; The Guardian newspaper, 2015).
43 Therefore issues affecting one country are likely to be applicable to others.

44 About 74% (5.4 million ha) of the land in Sierra Leone is considered arable but only
45 <15% is currently being cropped (Asenso et al 2009; CARD, 2009; Sannoh, 2011).
46 Sierra Leone has five major cultivable ecologies. These are upland (4.42 million ha),
47 bolilands¹ (145,000 ha), riverine lowlands (130,000 ha), mangrove swamps (20,000
48 ha) and inland valley swamps (690,000 ha). The agriculture sector is the major
49 employer in the country which is estimated at 70% of a population of about six million
50 people (Sannoh, 2011).

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

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

63

64 1.2 Pest control in Sierra Leone

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

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

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

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

101 **Materials and Methods**

102 **2.1 Study area**

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



124

125 Figure 1: Map of Sierra Leone showing rivers and districts

126

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

137

138 2.2 Methods

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

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

146 Where: z = 1.96 for 95% confidence level

147 p= percentage selecting a choice

148 C = confidence interval

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

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

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

152 The sample size was also verified using chi-square tests with the aid of SPSS
 153 SamplePower software. The sample size was proportionately divided to each of the
 154 12 districts in which rice cultivation is carried out. The proportion was calculated

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

160

161 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 | Kpengwea | 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 by 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 |

162

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

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

181 Discussions were also held with various stakeholders on the issue of pesticide use
 182 on rice fields including: a Parliamentarian who had a 0.61 km² rice farm and was a
 183 member of the Agriculture Oversight Committee in the Sierra Leone Parliament, a
 184 prominent member of the pest control unit at the Ministry of Agriculture, Forestry and
 185 Food security, an American environmental engineering expatriate and staff of two
 186 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

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

- 192 • Storage
- 193 • Handling
- 194 • Protection
- 195 • Preparation
- 196 • Application
- 197 • Surrounding activities (such as people working on the farm and adjacent
198 farms, eating)
- 199 • Effects on pest and other life forms

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

202

203 **2.3 Data analysis**

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

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

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

215

Results and discussion

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

221 **3.1 Prevalence of pesticide use by rice farmers in Sierra Leone:**

222 According to the FAO, (2011), 90% of the farmers in Sierra Leone are poor and can
223 only undertake subsistence farming which does not provide them with sufficient
224 funds to purchase pesticides. However the results obtained from interviews in this
225 study indicate that 86.4% of respondents use at least one type of pesticide on their
226 farms. This means the use of pesticides in rice cultivation is common in Sierra
227 Leone. It has also been stated that 60 – 70% of the work force in Sierra Leone are
228 farmers (FAO, 2014) and 80% of these are rice farmers (Encyclopaedia of Nations,
229 2014). Exposure to pesticides is not only limited to people considered to be within
230 the working age range which is between 18 and 65 years. It was also observed that
231 children as young as 8 years and farmers as old as 75 years are involved in farming
232 activities which involves direct exposure to pesticides. Both male and female farmers
233 are potentially exposed but from the focus group discussions it was revealed that
234 mainly boys and men between 15 to 60 years handle and apply pesticides on the
235 farms. This is an indication that most of the population in Sierra Leone comes into
236 contact with pesticides which could lead to significant negative health effects if these
237 substances are not handled properly.

238 **3.2 Types of pesticides used in Sierra Leone rice fields**

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

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

250 Data from interviews suggested that both the volume of carbolinium and the mass of
251 solid pesticides (furan) used does not depend on the size of the farm (carbolinium:
252 $U=6.000$, $Z=-2.449$, $p=0.014$; solid pesticides (furan): $U=7.000$, $Z=-1.273$,
253 $p=0.0203$). For the pesticides in solutions, such as chlorpyrifos, malathion and
254 propanil, the volume of pesticide used depends on the size of the farms ($U=10.5$,
255 $Z=0.306$, $p=0.759$). carbolinium and furadan are applied at various points within the
256 farms and not necessarily the whole farm. Hence the size of the farm does not
257 influence the quantity that is used. The pesticides in solution are mixed with the
258 seeds and then broadcast⁴. The quantity of seeds used is proportional to the size of
259 the farm and it is also directly proportional to the volume of pesticides required.
260 Therefore the bigger the size of the farm the higher the volume of pesticide required.
261 Interviews and field observation showed that the volume of pesticide in solution used
262 per bushel (27 kg) of rice varies from farmer to farmer. Sixty one percent of the
263 respondents who use these types of pesticides use 70 ml per bushel (27 kg) of rice,
264 15% used 35 ml per bushel, 11% use 140 ml per bushel and 9% use 105 ml per
265 bushel. About 4% used between 200 ml to 500 ml of pesticide solution per bushel.
266 The volume used depends on the purchasing power of the farmers and the size of
267 the farm. There is no prescribed threshold to limit the use. Such practice can lead to
268 over use and if this happens over a long period it may lead to chronic effects such as
269 sex-selective alterations of serotonergic synaptic function in adults (Gevao et al,
270 2000; Aldrige et al, 2004).

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

⁴ Broadcast: to scatter seeds on the field by hand

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

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292 Figure 2: Containers in which most pesticides are sold

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

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

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

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

309 3.3 Sources of pesticides

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

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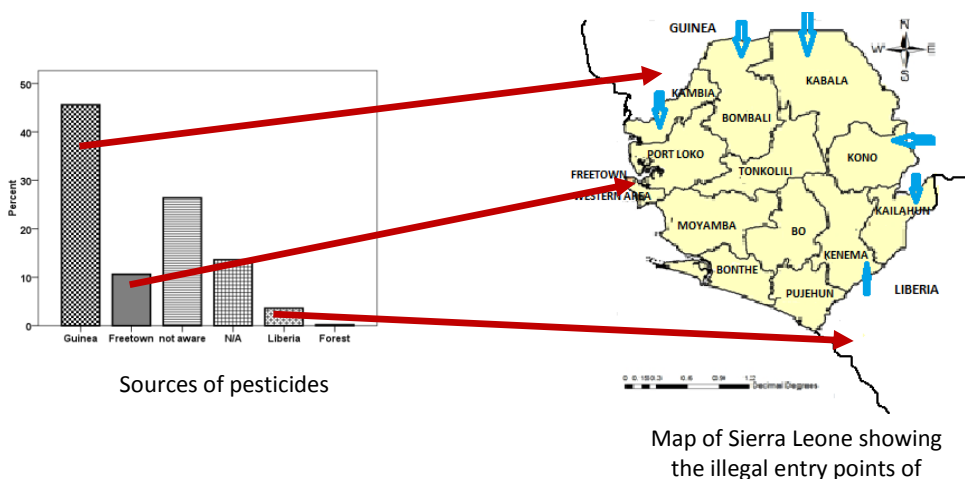
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327 Figure 3: Supply routes for pesticides to and within Sierra Leone. The bar chart
328 shows the percentage coming from various routes.

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

Comment [SAI1]: Should I delete this?



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

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

348 **3.4 Training and education**

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

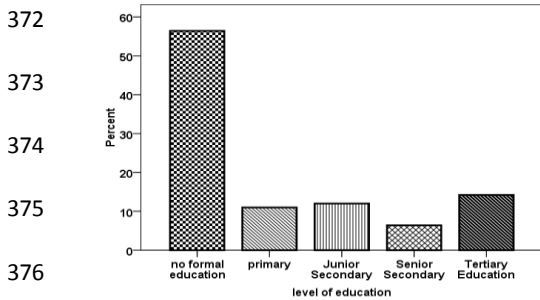
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355 However, there are groups of trained personnel present in major cities across the
356 country. Some of these are attached to government pest control units and some to
357 private pest control units. Most of these trained personnel are semi-illiterate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

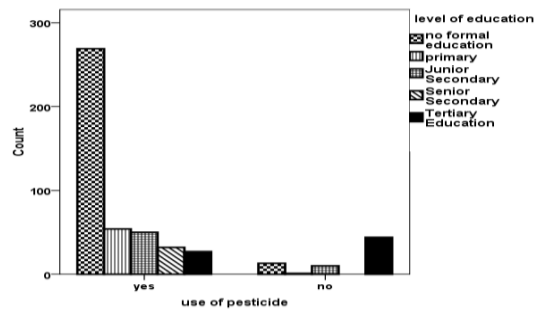
363 most of the time. Even these trained personnel do not know the differences between
364 some of the pesticides they use.

365 From the interviews, it was found that 56.4% of the farmers have no formal
366 education (Figure 4a). Twenty three percent (primary and junior secondary levels)
367 are not educated enough to understand instructions written on the labels. Only
368 20.6% of the respondents are considered to have adequate education to read and
369 fully understand instructions written on the labels. However 90% of those considered
370 having adequate education cannot read the instructions in French.

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377 Figure 4a: Level of
378 education of respondents



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

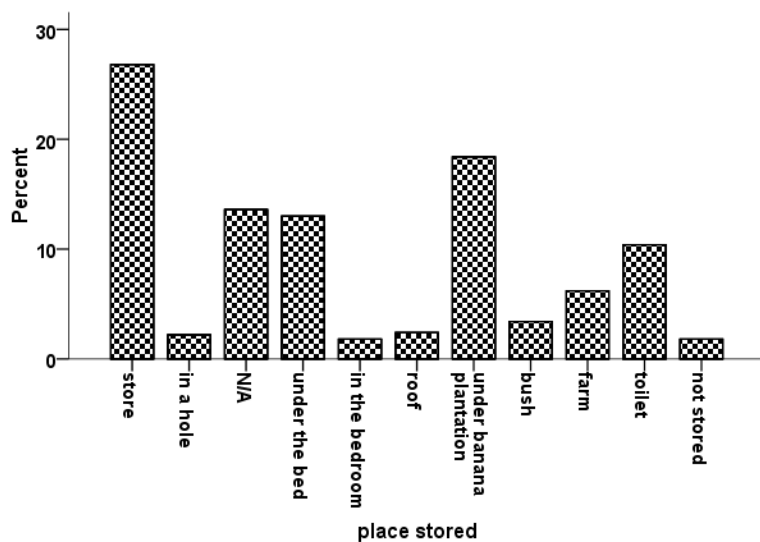
381 The educational categories represented in Figure 4a include both farmers that use
382 pesticides and those that do not. When cross-tabulated and subjected to a chi-
383 squared test, it was found that there is a significant difference in education levels
384 between those who use pesticides and those that do not use them ($p = 4.35E-$
385 30.004 , $T = 7.243$ Kendall's tau-b SE = 0.042, Sommers'd SE = 0.37). It was
386 observed that 62% (269) of farmers that use pesticides have no formal education
387 whilst 64.7% (44) of those that do not use pesticides have tertiary education (Figure
388 4b). The perception of people with no formal education can be much more difficult to
389 change than those with formal education (Ecobichon, 2001; Gaber and Abdel-latif,
390 2012). They tend to confine themselves to the first concept they learn. This means
391 most of the farmers would be unlikely to accept new methods especially if they are

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

395 **3.5 Storage and handling, application and exposure**

396 **3.5.1 Storage**

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



414

415 Figure 5: Places where pesticides are stored

416 **3.5.2 Handling, application and possible exposure routes**

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

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

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

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

441

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

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

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

456

457 **3.6 Environmental effects**

458 From the interviews, all respondents using pesticides admitted that pesticides kill
459 both target and non-target organisms. The non-target organisms mentioned were
460 snakes, worms, insects, mud skippers, rats, and farm animals. From results obtained
461 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

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

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

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

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

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

516 **4.0 Conclusion**

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

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

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

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

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

551 **5.0 Recommendations**

552 The following recommendations are made:

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

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