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Management of Empty Pesticide Containers—A Study of Practices in Santa Cruz, Bolivia

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ABSTRACT

AIMS: The mismanagement of empty containers of pesticides, posing a risk to the environment and the health of people, has motivated the promotion of international policies and guidelines to mitigate such problems. Despite these guidelines, attention to this problem is inadequate in Bolivia. The objective was to study the knowledge and practical management of the containers and to implement a responsible management plan for empty pesticide containers.

METHODS: This study implemented the project from 2014 to 2016 in 2 municipalities of the Department of Santa Cruz. Integral and participatory processes of information, education, and training were used. A questionnaire study among pesticide users was used to investigate knowledge and management of the empty pesticide containers.

RESULTS: The authorities and the population responded to the program by taking a critical and active approach to the problem, improving their responsible practices, and 5500 kg of empty containers were collected. The cross-sectional study showed that 93% of the empty containers were disposed of in vulnerable places; 62% of the population did not know what triple washing is; 60% felt discomfort, headache, and/or dizziness while using pesticides; and 31% of the empty containers had pesticide residue inside them.

CONCLUSIONS: The study illustrates a complex situation, mainly caused by lack of knowledge and clear guidelines. We recommend documentation of the social, economic, and productive characteristics of the region before any municipal program action is undertaken. The key element to sustainable change is an informed and coordinated participation of all actors.

KEYWORDS: Environmental, pesticide containers, occupational health, intoxication

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Introduction

As a consequence of current patterns of use and management of pesticides, the volume of empty containers generated is increasing, to the point of becoming a problem.[1–6] There is not enough information available to determine the number of empty containers generated annually, but it was seen that most of the containers were eliminated incorrectly and that 10% of the workers used them to store food and drinking water. This malpractice is extremely minimal, compared with other studies conducted in other regions of Ethiopia, where 77% of the farmers used the containers in various household contexts.[1] The empty containers of pesticides still had residues of pesticides inside them. So, even after they are used and emptied, they are considered hazardous waste that can cause damage to the environment and human health.[7,8] There is a danger that empty containers, when reused to store water and food, may lead to poisoning and that those left in the environment will generate pesticide contamination in soils and underground water sources. Numerous studies have shown, for example, that the level of 2,4-D exposure implies that people who drink water contaminated with 2,4-D have higher likelihood of deterioration of the hematopoietic system, nephrotoxic and/or hepatotoxic effects, and reproductive disorders.[7,8] In view of this situation, it is recommended that 2 essential tasks are implemented at the international level, namely, the use of triple washing and its subsequent disuse, to be conducted in rural areas, prior to any alternative use of the disposed empty containers. In addition to this, a comprehensive management policy is being promoted, with priority being given to avoiding the generation of containers at the source.[9] A management plan should ensure that the containers are decontaminated immediately after the use of their contents, preventing improper use of the empty containers and making it easy for users to return the empty containers. Despite all the guidelines and recommendations, attention to the problems associated with empty packaging has not been adequate, especially in developing countries.[10] Developing countries, compared with developed ones, do not have the necessary conditions (human, legal, technical, and economic) to implement a management plan.[9,10] Australia and France, developed countries, managed to collect 35% and 25% of the total of empty containers generated in 2003. These results show an increase in 41% when compared with the total of containers collected in 2002. However, this growth was

lower than expected, possibly because the consumption of pesticides in 2003 decreased by 10%. The situation is completely different in developing countries. Ecuador and Uruguay managed to collect 0% and 4% of the total empty containers generated in 2004, whereas in 2005, they collected 8.3% and 5%, respectively. In Bolivia, in addition to all of the above limitations, there are additional factors that further aggravate the problem, such as, on one hand, the rapid growth that occurred in terms of imported quantities and, on the other hand, the low levels of knowledge of farmers (small and medium) regarding the use and responsible management of pesticides. In 2002, of a total of 119 farmers interviewed, only 26% had received some type of training or information on the subject.

In 2014, the Bolivian nongovernmental organization Plagbol implemented the project, "Healthy food and environment," in which one of the main objectives was "To prevent pollution of the environment by promoting practices to minimize the problem created by pesticides and their used containers that remain in the environment after use." The objective was to study the level of knowledge and the practical management of the containers and to implement a responsible management plan for empty pesticide containers. Thereby, measures should be undertaken to help to diminish the danger of the empty pesticide containers and secure their final disposal through actions such as the triple rinse, installation of collection centers, and elimination of the containers.

Methods

Study population and design

The project was conducted from 2014 to 2016 in 2 municipalities of Santa Cruz and Pampa Grande, with a population of 9983 inhabitants, and San Julián with 53 275 inhabitants.

This study consisted of the following 2 parts: the first was a descriptive cross-sectional study investigating the knowledge and practices of farmers as assessed through a questionnaire and the second was the development of an integrated and participatory information, education, and training program, whose purpose was to contribute to the solution of empty pesticide containers.

The study population was selected from among farmers who volunteered and who used pesticides and were at home when the study took place, in 10 communities of Pampa Grande and 30 in the region of San Julián. With the help of local farmers, the communities were divided into 3 zones, with 4 to 5 interviews conducted in each of the zones. Using a motorcycle and starting at one end, we traveled through the zones, and when we met farmers, they were asked to participate in the interviews. They were informed about the objectives of the study, and nearly all wanted to participate.

Questionnaire, data collection, and analysis

The questionnaire included open-ended and multiple choice questions regarding background data, such as age, sex, years in farming, education level, previous pesticide training, knowledge, and practices related to pesticide use, symptoms of pesticide poisoning, and knowledge and practices regarding handling of empty pesticide containers. A class at the agricultural school was asked to complete the questionnaire and comment on errors and unclear word phrasing. The amendments were incorporated as proposed by the students.

Trained graduates of the agricultural colleges of Valle Grande and San Julián performed the data collection interviews, typing the answers into an Excel spreadsheet. The questionnaire was applied between July 2014 and May 2015, with personal interviews conducted with 361 farmers. Comparative statistics were made with SPSS software, comparing respondents above and below 45 years of age and respondents with and without some formal education. Descriptive data were presented in percentages, whereas the results on degree of knowledge were calculated using χ^2 test and Students t test. The local ethical panel approved the study—this is added in the "Methods" section.

Intervention

The intervention program entitled "responsible management of pesticide containers" was implemented from June 2015 to August 2016 and was divided into 2 stages.

Planning and coordination

A training program and a dissemination strategy were developed in agreement with the major stakeholders, the municipal authorities, farmers' union officials and other civil society institutions, and the steering committee. The training sessions focused on integrated pest management (IPM) and proper management of empty pesticide containers, with triple rinsing and puncturing of the containers to prevent reuse. The training was based on a participatory adult training methodology. In the method developed by the United Nations Educational, Scientific and Cultural Organization, the students are more responsible for learning than the teacher. The dissemination strategy was based on the use of mass media, such as roadside billboards, a poster, a brochure, a video, and radio programs.

Implementation

The training courses, the information dissemination, and the campaigns for collecting empty containers were launched among the municipal authorities, farmers' union officials, and other civil society institutions. The containers were collected in agreement with a plastic recycling company.

Results and Discussion

A total of 361 farmers, mainly men, were included, with an average age of 42 years, all with a low level of formal education (Table 1).

Another aspect of Table 1 worth highlighting is that 97% of the evaluated farmers use pesticides, but very few had received

Table 1. Background characteristics of farmers in Santa Cruz, Bolivia, 2015 (n = 361).

VARIABLE	NO. (%)	95% CI
Age, y (average, range)	42 (22–72)	
Gender		
Women	12 (3)	0–7
Men	349 (97)	92–99
Education level		
Illiterate	4 (4)	1–9
Primary school	77 (74)	64–81
Secondary school	21 (20)	13–28
Technical university	2 (2)	1–28
Years of pesticide use		
1 to 5	85 (24)	19–28
6 or more	268 (76)	71–80
Hours of fumigation per day		
1 to 5	161 (46)	40–51
6 or more	190 (54)	48–59
Pesticide training		
Has received training on pesticide use, yes	155 (43)	39–49

Abbreviation: CI, confidence interval.

previous training in pesticide use, and thus did not have the skills and knowledge for responsible management and use of pesticides. Therefore, it is not surprising to see in Table 2 that most farmers say they smoke, chew coca leaves, and/or eat when applying pesticides in the field. They claim to use personal protection equipment (PPE), even though, when asked to specify, it turns out that most of them are clearly not using the recommended PPEs (data not shown). They usually just use "other clothing" when applying pesticides, based on the International Standards Organization recommendations for safe clothing, or they use just rubber boots and/or glasses.

Supported by these results, as presented in Tables 1 and 2, we not only see that the pesticides are an important source for generating hazardous waste, but we also see that the farmers constitute a high-risk group for suffering from pesticide poisonings.

Interestingly, the farmers who have previously received some training on pesticide use report more symptoms than the ones who have never received any training. This difference is not statistically significant and is also hard to judge completely, as the type, duration, and time gap between the training and the present are very diverse. Therefore, data are not shown. However, it could indicate that trained farmers are more aware of symptoms and thus more likely to report.

Table 2. Practices and knowledge regarding *pesticide use* for farmers in Santa Cruz, Bolivia, 2015 (n = 361).

VARIABLE	%	95% CI
Practices when handling pesticides		
Take shower after fumigation	98	97–99
Buy pesticides in original packaging	96	94–98
Read labels on the pesticide packaging	80	75–84
Understand the information on the label	76	71–80
Use personal protection equipment when applying pesticides	71	65–75
Chew coca leafs, eat or smoke when fumigating	59	54–64
Knowledge about pesticides risks for the health and the environment		
Thinks that pesticides can cause harm to human health	99	97–99
Thinks that pesticides can cause harm to the environment	96	92–98
Has at least once felt discomfort while using pesticides	61	56–66
Nausea	61	56–66
Headache	58	52–63
Dizziness	45	40–50
Tiredness	43	38–48
Muscle weakness	33	28–38
Irritated skin	29	24–34
Blurred vision	27	23–32
Respiratory difficulty	22	18–26
Salivation	19	15–23
Concentration difficulties	15	12–19
Hand trembling	15	12–19

Abbreviation: CI, confidence interval.

With respect to the handling of empty pesticide containers, we see that most farmers do not know the benefits of the triple rinse, nor perform it (see Table 3). However, those farmers who say they do perform the triple rinse, due to their low level of knowledge on how to perform the procedures for this activity (rinse 3 times and perforate the container), often only rinsed the containers with water 1 or 2 times. Something to note is that none of the farmers perforated the containers or used the appropriate volume of water necessary to reduce the hazard and ensure appropriate removal of the pesticide.

Table 3 shows some of the main problems related to handling empty pesticide containers. The places for disposal of empty containers were inappropriate, often situated outside of

Table 3. Practices and knowledge regarding *empty pesticide containers* for farmers in Santa Cruz, Bolivia, 2015 (n = 361).

VARIABLE	%	95% CI
Practices when handling empty pesticide containers		
Place of the final disposal of the empty pesticide containers		
Outside the house	93	90–96
Inside the house	6	4–9
What do you do with your empty pesticide containers?		
Throw out	51	45–55
Burn	50	45–55
Bury	8	6–11
Sell	8	6–11
Return	5	3–7
Perform the triple rinse	155/361 (43)	38–49
Knowledge about empty pesticide containers		
Thinks that pesticide residues are always visible	31	26–36
Thinks that empty pesticide containers can cause harm to human health	99	97–99
Thinks that empty pesticide containers can cause harm to the environment	85	81–89
Knows all the steps of the triple rinse (rinse 3 times and perforate)	38	33–43
Knows the purpose of the triple rinse	41	35–46

Abbreviation: CI, confidence interval.

houses, in plots near water sources or inside the house, generating spills, and/or vaporization processes. Another problem was revealed by the inspections, which showed that most of the containers were open and about one-third had pesticide residues inside. The producers used different forms of elimination of the containers and none of them complied with the requirements. For example, to prevent air pollution from hazardous toxic gases, temperatures above 1200°C or specific filters are required when burning empty containers. Knowledge and practice regarding pesticide handling in general (Table 2), and the handling of empty pesticide containers in particular (Table 3), were analyzed according to age groups and educational level, with no significant differences found.

Intervention into responsible management of empty containers

Generally, the results of the intervention project were positive, resulting in the use of responsible practices in handling, collection, and disposal of empty containers. Among the results and lessons learned during the different steps, we want to highlight the following:

Step 1. Except for some minor problems in the beginning with delay in constituting of the committees, the collaboration with the stakeholders was perfect. Municipal governments contributed 20% of the budget and Plagbol 80%. In addition to this, there were supplemental contributions from other institutions, such as the National Program of Vegetables (Spanish: Programa Nacional de Hortalizas [PNH]) and the UNAMAZ project of the University Gabriel Rene Moreno's contributions of financial and human resources (see Photo 1).

Photo 1. Plagbol handing out educational/informative material to the municipalities, 2014.

The results of this work are as follows:

1. Courses were generated for the main trade union and municipal authorities, achieving the participation of 480 people (90 officials and 390 farmers). Their knowledge was increased, and this resulted in the organization and execution of the collection campaigns (see Photo 2).

Photo 2. Group discussion during courses on pesticides and triple rinse, 2015.

2. Two collection centers for empty pesticide containers were established. In the Municipality of Pampa Grande, 17 local mini storage centers were installed with support from PNH (see Photo 3).
3. A technical team (consisting of PNH staff in Pampa Grande and Plagbol staff in San Julián) was trained to teach the farmers within the communities on IPM and proper handling and collection of empty pesticide containers.

Photo 3. Community collection center for empty pesticide containers in Pampa Grande, 2015.

4. Different types of educational and information materials were developed and disseminated which included 4 billboards, 4000 posters, 4000 leaflets, 1 video, and a 4-part radio program (see Photo 4). It is worth noting that the training programs and the educational materials were used by the PNH in 6 of the 9 departments of Bolivia, thus extending the project initiative far beyond the project areas.

Photo 4. Billboard about triple rinsing in San Julián, 2015.

Step 2. After the working conditions were established, the courses were delivered within the communities (Photo 5). The courses for the communities involved more details concerning IPM. To raise the interest of the population, the educational materials were disseminated through radio programs and information sheets distributed at some fairs (Photo 6). The project later managed to make an agreement with the plastic recycling company to pick up and transfer

Photo 5. Informative training sessions in the local communities in San Julián, 2015.

Photo 6. Farmer product fair in San Julián, 2015.

the empty containers from the collection centers to its own recycling facilities. In addition, this company pays the sum of $0.114 per kilogram of pesticide containers. Although this is not a large sum of money, it will be used by the autonomous municipal governments to continue the work of collecting empty pesticide containers.

Step 3. The Committee planned and coordinated the campaigns for collecting the empty containers, with the primary focus on containers tossed around in nature, which have to be retrieved one by one. To encourage a high rate of participation in the campaigns, mass media communications and posters were disseminated among the population, and contacts with the authorities in the municipalities were established. Two campaigns were performed in Pampa Grande and 1 in San Julián (see Photos 7 to 9). All communities (32) in Pampa Grande were reached during a 12-day period, whereas in San Julián, only 10 communities in the districts

Photo 7. Collection team during the campaigns collecting empty pesticide containers, 2016.

Photo 8. Campaign for collection of empty pesticide containers, 2016.

Photo 9. Mini collection center for empty pesticide containers, 2015.

of La Asunta, Montenegro, and Illimani were reached. A total of 5.5 tons of empty containers were collected (2.5 in Pampa Grande and 3 in San Julián) and picked up by the plastic recycling company (see Photo 10).

Photo 10. Transfer of the empty pesticide containers from the municipalities to the plastic recycling plant, 2016.

Strengths and limitations

To our knowledge, this is the first study to both identify the gaps in knowledge and lack of safety practice regarding the handling of pesticide containers and present a solution founded in a comprehensive, participatory, and dynamic public health strategy, including the cultural and economic characteristics of the population. The positive results achieved through simple means make similar nationwide efforts easy to replicate. This will involve the establishment of partnerships, training, and advocacy in all political and professional areas of the communities.

Among the study limitations are the lack of identification of the proportion of the empty containers that did meet the 2 essential tasks: triple washing and perforation. Moreover, the number of pesticide containers tossed around in nature in the 2 intervention areas is not known; thus, it is not known how large a percentage the campaigns collected. The selected study population was too small (type 1 error) to note any statistically significant differences among different parts of the population. To determine sustainability, a follow-up study is needed to show whether the changes in attitude and commitment of the stakeholders are strong enough to result in operational and sustainable actions.

In searching the academic literature, we did not find any proven good solutions in the developing countries. Similar to our experiences, an Egyptian study showed a high level of unsafe use of pesticides and inappropriate methods of disposal of empty pesticide containers.[11] They also showed a similar lack of knowledge to what we found.

The results of the study reveal 2 problems that are caused by the mismanagement of pesticides and their empty containers, giving us the necessary evidence to generate processes of *avogacia* that facilitate and support decision-making at the political level, not only to make changes and/or adjustments in our regulatory systems but also to generate a specific national policy from this normative, conceptual, and strategic frameworks. In addition to the evidence, the study contributes to the elements, tools, and technical guidelines required to implement a policy that is more specific to the management of hazardous waste, such as the Law on Integral Waste Management Law 755, which although offers principles and guidelines for waste management still leaves a vacuum regarding the handling of hazardous waste, as is the case in the packaging of pesticides. In other parts of the world, there are national solutions in place that can be used as models for solving the problem. In Denmark, the empty pesticide containers must by law be returned to the retailers. They are obliged to receive them and resend them to the national chemical destruction plant, "Kommune Kemi," for safe recirculation of the plastic. The World Health Organization and Food and Agriculture Organization have comprehensive guidelines for safe management of the containers.[12] In Latin America, the Pan American Health Organization offers similar detailed guidelines for safe management of the containers.[13]

Conclusions

Improper knowledge and handling of empty pesticide containers is common among Bolivian farmers and poses a health risk to humans in the form of environmental pollution.

By including key stakeholders, such as the municipalities, national agricultural programs, and farmers, in planning and in raising awareness of the importance of preventing environmental pesticide pollution, an understanding of the need for action can be created.

This type of understanding created campaigns for the recollection of tons of empty pesticide containers within the environment and offered a solution to a final disposal through the reuse of the containers in a plastic-producing factory.

Such activities need to be adopted and facilitated by the authorities and Ministries of Environment, Health and Agriculture and together with efforts from the pesticide companies might result in a sustainable solution to this serious environmental problem. There is a significant challenge for developing countries to develop sustainable policies with education, training, legal regulations, and infrastructure for adequate handling of the empty pesticide containers.

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Author Contributions

OH, EJ, and GC conceived and designed the experiments. OCJ analyzed the data. OH wrote the first draft of the manuscript. MS contributed to the writing of the manuscript. OH, EJ, OCJ, MS, and GC agree with manuscript results and conclusions. EJ and MS jointly developed the structure and arguments for the paper. OH, OCJ, and GC made critical revisions and approved the final version. All authors reviewed and approved the final manuscript.

Disclosures and Ethics

As a requirement of publication, author(s) have provided to the publisher signed confirmation of compliance with legal and ethical obligations including but not limited to the following: authorship and contributorship, conflicts of interest, privacy and confidentiality, and (where applicable) protection of human and animal research subjects. The authors have read and confirmed their agreement with the ICMJE authorship and conflict of interest criteria. The authors have also confirmed that this article is unique and not under consideration or published in any other publication, and that they have permission from rights holders to reproduce any copyrighted material. Any disclosures are made in this section. The external blind peer reviewers report no conflicts of interest.

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