CHALLENGES OF CONTROLLING POLLUTION FROM THE USE OF CHEMICALS IN RURAL AREAS OF DEVELOPING COUNTRIES

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Abstract
The rapid expansion of industry and extensive promotion of commercial farming in Uganda, have led to use of large quantities of chemicals since 1994. In particular, the increased use of agrochemicals has put many peasant farmers at risk because they lack of training in the proper handling, use, storage and disposal of the chemicals. Suppliers of agrochemicals to the farm are ill equipped to provide advice because they do not comprehend chemical properties and scientific findings on exposure and effects of the chemicals. This explains the poor storage and disposal methods of pesticides and their presence in agricultural produce in Uganda. Various pesticides used mainly in agriculture have also been detected in soil, water, fish and weeds in Lake Victoria and in the rivers that enter the northern part of the Kenya Gulf of the lake. The gross economic product of the lake catchment is in the order of US$3-4 billion annually, and supports an estimated population of 25 million people who are at risk because of the chemical pollution to the lake.

Introduction
The handling of pesticides in developing countries presents a challenge in any effort aimed at controlling chemical pollution. The control methods must address not only the varied nature and effects of the huge number of chemicals but also the varied perceptions of what chemicals represent to the users and the level of understanding the risks involved in the different countries. In Uganda, growth in industrial output has averaged over 10% per annum since 1991. Most of the industrial activity is based on agricultural commodities and natural resources products. The growth in industrial production is accompanied by increased levels of air, water and soil pollution. Currently, the pollution effects are only being mitigated to some extent using the environmental assessment processes and cleaner production procedures.
Uganda lacks a functional registration and legislative framework and, as a result, the importation of pesticides is largely uncontrolled. In addition, there are no pesticide residue coordinated monitoring programs. Uganda Revenue Authority, the government agency responsible for authorizing the entry of imported chemicals, has no laboratory facilities to identify the pesticides entering the market and only classifies the imported pesticides for purposes of import revenue collection[1]. In rural areas at the district level, the management of chemicals and drugs falls under the jurisdiction of administrators or policy implementers. In spite of the above regulatory measures, chemicals have been abused in many places. Pesticides have been previously misused in killing bird pests and in fishing[2]. The detection of endosulfan in poisoned fish from Lake Victoria in 1998 led to the banning of fish from the European market and drastically affected the economy of Kenya, Uganda and Tanzania[3]. Previously, a number of POP pesticides had been detected in a variety of matrices including human adipose tissues and milk[4, 5]. Some recent studies indicate current use of organochlorine pesticides for agricultural and vector control programs [1, 6]. The aim of this study was to determine the type of pesticides used in the country and correlate them to those detected in vegetables, fish and sediments of Lake Victoria.

Materials and Methods
The first part of this study was carried out in western Uganda in a set of four districts of Rukungiri, Bushenyi, Ntungamo and Mbarara and the central districts of Kampala, Wakiso and Mukono. This set districts was selected because of the large numbers of livestock and improved farming methods– activities which necessitate the wide spread use agrochemicals /veterinary drugs in the region. The districts were also selected because the town ships in these districts are growing at a very fast rate and a large number of small-scale industries have been initiated in the townships. The second set of districts was selected because of the extensive commercial farming in the area and the increased importation of agrochemicals in the country. Chemical pollution in this area can adversely affect the fish export of the three countries of Kenya, Tanzania and Uganda which share the lake, but also the health of people who use the water and the fish from the lake. These districts are farming areas located in the central region of Uganda around Lake Victoria. The study targeted suppliers of drugs and chemicals as well as district officers, whose departments are in one way or another involved in the management of chemicals and drugs. The study was executed by holding face-to-face informal interviews with the major stakeholders including the District Veterinary Officer (DVO), District Agricultural Officer (DAO), and District Medical Officer (DMO), District Environment Officer (DEO) and District Drug Inspector (DDI) and selected end users. In the second set of districts, 171 farmers, 56 suppliers of pesticides and 55 policy implementers were interviewed.

The second part of the study consisted of analysing sediments of Lake Victoria, and fresh produce on farm and on the urban markets in the lake region for pesticide residues.
A gas chromatography (Varian 3800-CP) equipped with a Nitrogen Phosphorous Detector (NPD) and an Electron Capture Detector (ECD)was used for analysis. Extraction of sediment samples for pesticides was done by a solid dispersion method while the cleanup of sediment extracts was done using a gel permeation chromatography (GPC) [7]. Confirmatory tests within the laboratory were done using a dual column and dual detector approach coupled with a sulphuric acid treatment of selected extracts. Inter-laboratory confirmation of the samples was done at the Food and Environmental Toxicology Laboratory of the University of Florida, USA, using a Perkin Elmer GC equipped with both ECD and NPD.

Results and Discussion

Back ground education of respondents

The inventory on pesticide usage in Uganda covered policy implementers and selected end users in western Uganda. In central Uganda it covered 180 farmers and 62 dealers and 60 policy makers in the districts of Kampala, Mukono and Wakiso. The survey established that there is no systematic way for destroying and/or disposing of expired drugs, pesticides and other chemicals at the districts. This led to accumulation of large quantities of expired drugs. The districts had no policy and procedures on solid waste management. In the central districts of Uganda, 81.8% respondents involved in policy implementation were male. The majority of the policy makers were between the ages 40 to 50 years and 60.0% of them had attained the equivalent of high school and college education respectively. On the other hand, out of the 171 farmers interviewed, only one fifth (19.3%) of farmers were the equivalent of college graduates. The large majority of the farmers may never have been exposed to any basic knowledge on chemicals during their studies.

Familiarity with rules and Regulations on pesticide use

The majority (90.9%) of policy makers were aware of the policy on pesticide registration before use. The registration process enables authorities to exercise control over quality, use of labels, packaging, advertising, and disposal of pesticides, thus ensuring that the interests of end-users are properly protected. In the process of registration, the responsible national government authority approves the sale and use of a pesticide following the evaluation of comprehensive scientific data demonstrating that the product is effective for the intended purposes and does not pose an unacceptable risk to human or animal health or to the environment. In the three districts of Kampala, Wakiso and Mukono, 34.5%, 34.5% and 30.9% of the policy makers were aware that pesticides had to be registered before end users accessed them. The main reason for the low awareness was attributed to the fact that the central government had not implemented any pesticide registration and control scheme at the district level. All the farmers in the three central districts asserted that they were familiar with rules and regulations pertaining to pesticide use. However; the farmers did not demonstrate the knowledge and, on probing it was established that only 16.8 percent of the farmers were aware that pesticides had to be licensed first. Only one third of the farmers (30.2 %) were aware that pesticides had to be kept away from children. Over half of the farmers (61.1 %) were aware that pesticides should be applied following written guidelines. This is in agreement with the percentage of farmers who had participated in the training courses on safe usage of pesticides. A small fraction (12.8 %) of the farmers considered proper storage of the pesticides to be the most important aspect the regulations on the use of pesticides

Personal health and Safety Concerns

Out of the 171 farmers interviewed, 47 (27.5%) did not use any protective gear while applying pesticides. On the other hand, a good fraction (87.9 %) of the farmers used gloves for protection, although a small number of farmers (29.8 %) used respirators for protection. Higher usage of disposable gloves can be attributed to the fact that they are cheap and easily accessible in comparison to the respirators. A small fraction of the farmers (15.3%) used overalls for protection of whole body while a larger fraction(82.5 %) of farmers do not wear glasses for eye protection.74.9 % of farmers bathed and changed into clean clothes immediately after spilling small amounts of pesticides on their clothing while 17.5% of the farmers did not consider it urgent to change into clean clothes. The use of protective wear during pesticide application did not vary significantly from district to district ($p = 0.513$), implying that the proportion of farmers using them in different districts was more or less the same. The low applications of safety gear may be attributed to the fact that that most farmers are ignorant of the risks involved in handling the chemicals.

Disposal of unutilized and Expired Pesticides

26.3% of the farmers had problems with disposing their stocks before date of expiry. On average, the three districts had 3.5 kilograms of disposable stocks per farmer. Farmers in Wakiso had the highest stocks at 13 kilograms followed by Kampala and Mukono at 0.286 kilograms and 0.218 kilograms respectively. Given an average of 3.5 kilograms of obsolete piles per household this amounts to 747,904.5 kilograms of stock piles that are held by farmers in the central region alone. Taking into account the number of suppliers in each district, on average each dealer had a staggering quantity of 253 kg at the time of the survey**.** None of the farmers used recommended ways of getting rid of the stock of chemicals. Most farmers either bury chemicals in pits (23.1%) or empty into a pit latrine which may find their way into water sources if nearby (25.6 %). The pattern of methods used by dealers to dispose off expired stocks was almost similar to that used by farmers indicating that lack of knowledge by both parties contributes to the health hazards posed by both dealers and farmers.

Summary of pesticide residues in selected matrices

Table 1 shows the levels of pesticide residues on the Kenya side of the lake. The pesticides frequently detected were mostly organochlorine pesticides which were detected in at varying frequencies and concentrations in water and sediment of two tributaries and two beaches. Generally higher levels of residues were detected in river sediment and water than in the lake. The levels for DDT, HCH, methoxychlor and endrin were below the WHO limits guidelines for drinking water, whereas those for aldrin, dieldrin, heptachlor, heptachlor epoxide and endosulfan were above recommended values. Table 2 shows the pesticides detected in the lake in four bays. The organochlorine pesticides were again detected in varying low amounts. With the exception of endosulfan, Chlorfenviphos(1) and Chlorpyriphos,none of the pesticides are registered for use in Uganda.Their detection in sediments and water implies either contamination of the pesticides currently being used by farmers or arising from atmospheric deposition and calls for coordinated efforts by the riparian states aimed at minimizing the levels.

Pesticides	River Sio (n=9)		River Nzoia (n=9)		Sio Port Beach (n=9)		Marenga Beach (n=9)	
	Water(µg/l)	Sediment (µg/kg)	Water(µg/l)	Sediment (µg/kg)	Water(µg/l)	Sediment (µg/kg)	Water(µg/l)	Sediment(µg/kg)
α- HCH	0.02-0.03	3.55-5.16	0.01-0.04	3.87-6.94	0.01-0.05	1.81-6.06	0.01-0.3	0.91-7.78
β- HCH	0.01-0.05	2.7-4.00	0.01-0.06	1.34-4.19	0.01-0.05	0.92-3.59	0-0.10	0.52-2.33
γ- HCH	0.04-0.11	2.07-18.25	0.04-0.06	5.56-27.09	0.05-0.09	6.23-24.54	0.03-0.07	3.37-23.12
p,p'- DDT	0.02-0.13	2.56-19.39	0.07-0.09	14.73-20.42	0.07-0.09	7.16-12.57	0.01-0.09	1.62-12.32
o,p'- DDE	0.08-0.16	3.97-13.87	0.02-0.15	9.63-10.62	0.02-0.09	0-6.12	0-0.09	5.15-10.53
p,p'- DDD	0.02-0.10	9.11-39.54	0.08-0.08	21.56-24.20	0.07-0.14	13.16-19.49	0.04-0.18	10.72-18.91
α- Endosulfan	0.12-0.23	116.50-25.50	0.05-0.11	11.04-49.11	0.02-0.15	5.96-22.47	0.06-0.13	0.12-13.45
Endosulfan	0-0.19	11.26-15.56	0.07-0.10	10.32-25.97	0.01-0.15	2.88-13.17	0.07-0.14	6.72-13.06
β- Endosulfan	0.09-0.18	0.01-0.32	0-0.14	0.2-0.12	0.03-0.09	0-0.05	0-0.09	0-0.03
Aldrin	0.17-0.34	6.15-57.32	0.03-0.20	9.41-27.76	0.07-0.14	11.71-12.71	0.05-0.10	11.44-20.78
Dieldrin	0.07-0.10	22.07-65.48	0.18-0.36	30.65-51.92	0.09-0.18	16.03-57.01	0.12-0.31	11.94-69.55
Endrin	0.03-0.17	7.07-12.76	0.05-0.22	14.07-26.86	0.18-0.11	8.64-18.13	0.04-0.09	8.00-10.99
Heptachlor	0.03-0.17	8.25-16.59	0.10-0.15	17.24-27.99	0.08-0.15	2.49-10.00	0.05-0.10	13.76-30.83
Heptachlor epoxide	0.03-0.15	3.40-40	0.06-0.12	4.06-21.70	0.08-0.15	3.20-8.76	0.05-0.11	3.24-6.31
Methoxychlor	0.02-0.86	2.16-8.13	0.02-0.08	7.82-37.47	0.04-0.07	2.52-14.78	0.02-0.14	3.45-4.41

Table 1: Comparison of pesticide residues levels in water and sediments from Rivers Sio, Nzoia and Lake Victoria (µg/l)[8] .

Sediment	Napoleon Gulf	Murchison Bay	Thurstone Bay	Waiya Bay
HCH- gamma	0.74 – 6.52	0.21 – 3.72	1.59 – 2.62	ND – 4.88
Aldrin	ND – 3.75	ND – 3.75	ND – 2.14	ND
α-Endosulfan	2.84 – 14.32	0.96 – 23.77	5.37 – 18.45	3.07 – 12.63
p,p'-DDE	ND – 4.58	ND – 2.76	ND – 1.68	ND – 0.71
p,p'-DDT	3.56 – 9.73	0.93 – 11.25	0.05 – 5.66	ND – 1.44
Chlorfenviphos(1)	ND -13.56	ND – 5.78	ND - 7.18	0.83 – 7.94
Chlorpyriphos	ND – 26.81	ND	2.34 – 42.08	4.55 – 14.23
Heptachlor epoxide	ND- 6.05	ND-11.17	ND-8.92	ND-4.75
Chlordane	ND – 2.65	ND – 8.07	ND – 4.32	ND

Table 2: Pesticide levels in Lake Victoria sediments (µg/Kg).Source: Wasswa 2006(un published)

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