# PESTICIDE MANAGEMENT IN SRI LANKA

## Implementation Issues & Past Experience

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### Agricultural productivity

Sri Lanka is an agricultural country with a population of around 19 million people and account for nearly 22 percent of the foreign exchange from the exports of agricultural commodities. Contribution to the GDP from agricultural sector has been declining in the last couple of decades from 40 percent in 1960's to 17 percent in 1999. Agricultural sector absorbed 34 percent of the labour force in 1994. As a result of the decrease in agricultural production during the last decade the overall agricultural production index recorded as 118 in 1991 against 132 in 1986. On the other hand, spending on food imports have increased from Rs.16 million in 1991 to Rs.26 million in 1995. Compared with countries of South Asia, Sri Lanka has a high population density of 0.35 ha per person. Out of total land area of 6.5 million ha only about 5.5 million ha are arable. Thus, it is vital that the production efficiency in agriculture sector be improved both in production and post harvest aspects.

Food security has been a major policy goal of successive governments. Seventy four percent increase in the extent of rice cultivated area has been achieved during the last five decades. The fact that agricultural commodities are freely imported at comparatively very low prices due to recent changes in the international and regional trade practices, local cultivation of seasonal crops are now fast becoming uneconomical. Thus farmers are compelled to switch over to low input cost, increased yield and reduced production cost options, where possible. Average labour cost component of the most extensively grown seasonal crop of the country, paddy, is still around 50 percent of the inputs.

Rapid increase in labour cost in the recent past left chemical alternatives as significantly low cost option available especially for weed control. As a result, paddy farmers are now almost totally dependent upon chemical weed control. In the case of vegetables, there is an increasingly high market price for pest and disease free "extra clean" produces. This trend is further aggravated by the high prevalence of pest attacks in some improved high yielding varieties and high cost involved with other advanced technological options. In order to cater to the demand for increased productivity, farmers depend excessively on pesticides for crop protection.

### Pesticide import and consumption

Pesticides are considered as the most toxic group of chemicals, meant to use, in most often in the local context, by a vast majority of the population who are virtually unskilled. The group of chemicals consists of products ranging from household items to extremely hazardous products used only by professional applicators such as fumigators. Because of its versatile nature of users, pesticides naturally become the most hazardous products in common use.

Pesticides are imported into the country either as ready-to-use products (formulations in retail packs or in bulk for re-packing) or as technical material for local formulation. By 2000 the CIF value of the country's pesticide requirement was 1349.5 million rupees and of this 270.6 million rupees was allocated for the import of technical material for local formulation. Of this 1078.9 million rupees was allowed for direct import of formulated products (Table-1).

**Table 1**
**Foreign exchange allocated for import of pesticides-2000**

| *Item* | *Volume in Metric Tonnes* | *Value in Rupees* |
|---|---|---|
| Insecticides | 1294.5 | 431,021,080 |
| Weedicides | 2138.3 | 710,543,760 |
| Fungicides | 570.9 | 161,545,600 |
| Others (acaricides, rodenticides, fumigants, molluscicides, insect repellents, etc.) | 124.3 | 46,442,840 |
| **Total** | **4128.0** | **1,349,553,280** |

*Source:* Pesticide Statistics for the Year 2000, Office of the Registrar of Pesticides

At present, approximately 50 insecticide active ingredients, 30 fungicide active ingredients and 25 weedicide active ingredients are registered for marketing and use in Sri Lanka. Total annual pesticide consumption was estimated as 1696 metric tonnes of active ingredients at a cost of 4628 million rupees in 2000.

### Pesticide use patterns

As speaks above, the use of pesticides remains as an indispensable crop protection tool in Sri Lanka. According to WHO/UNEP data for the year 1992, latest available, of average load of pesticides applied on the environment, Sri Lanka ranks above Africa and Latin America with 1,013 g/ha that of Latin America. The Sri Lankan situation is comparable with the highly industrialised nations such as USA (1,490 g/ha.) and Europe (1,870 g/ha). However, those developed countries possess all latest advancements in technologies along with infra-structural and economic support properly in place to ensure the safe use and avoid any adverse environmental and human health impacts of pesticides. As a result of extensive and indiscriminate use of pesticides, numerous problems have surfaced. A lot has been written about pesticide mal-practices in Sri Lanka and the consequent number of poisoning cases reported by the National Poison Information Centre. Although a majority is suicidal nature, nevertheless, the message has come across that there is a need to safeguard the health of the applicators, and this has indeed become one of the greatest concerns of the Registration Authority. Economic constraints prevent facilitation of highly sophisticated technology required for close and careful monitoring of the field situation, investigation of root, causes of problems, making the required remedial measures and proper record keeping in most human

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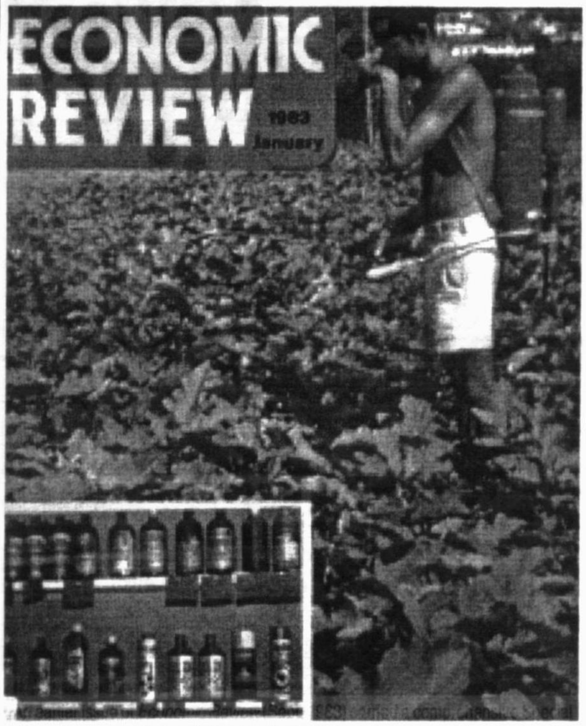



An earlier issue of *Economic Review* (Sept. 1983) carried a comprehensive Special Report on pesticides in order to highlight the emerging issues in this field and to sensitise the policy makers on the urgent need for stringent regulatory mechanisms.

health and environment related incidences. Therefore, it is feared that unnoticed and unknown ill effects would be much higher than it appears.

**Pesticide legislation**

The Control of Pesticide Act No.33 of 1980 clearly identifies the framework for pesticide regulation in Sri Lanka. It makes provisions to regulate the import, formulation, packing, labeling, storage, transport, sale and use of pesticides. Thus it is evident that the law applies to all pesticides, whether the end use is in the fields of Agriculture or Public Health, or whether the products are to be used in the Household or in Industry.

In Sri Lanka, the responsibility for administering pesticide legislation is vested in the Department of Agriculture. The Registrar of Pesticides is the Licensing Authority, who is advised on policy and technical matters by the Pesticide Technical and Advisory Committee (PeTAC). The Registrar of Pesticides is further assisted in an informal manner with expertise available in the Department of Agriculture and other government institutions.

The basis of regulation is the compulsory registration of all pesticide material. The objective of registration is:

(a) To provide an efficient process for the systematic review and approval of pesticide products prior to import, formulation and marketing.

(b) To ensure that pesticide products that are allowed enter into the market is supported by data that demonstrates safety and efficacy.

(c) To screen products that may cause undue harm to humans and/or the environment.

(d) To provide review and approve of individual pesticide labels and advertisements.

(e) To ensure an effective field enforcement mechanism for monitoring of proper distribution, storage, sale and use.

It is a continuous review process usually carried out through an evaluation of data provided by the registrant and available through the international agencies and regulatory authorities whereby the Registration Authority approves the sale and use of a pesticide. This process is a comprehensive evaluation of scientific data demonstrating that the product is effective for the purpose(s) intended and not unduly hazardous to humans, to animal health or to the environment. If every pesticide is registered the public will know at a glance that the product on sale has satisfied the requirements of the law on its safety and effectiveness when used according to the directions on the label. This qualification "when used according to the directions on the label" is important as no regulatory agency can guarantee the safety against misuses.

**Pesticide use:**

***Mal-practices, resistance and other environmental concerns***

The estimations reveal that the total amount of released pesticide active ingredients into the environment is more or less stable since 1995 (**Table 2**). The continuous dependence on use of pesticides had brought about a great degree of awareness of the potential hazards posed by their indiscriminate use. A number of studies have shown pesticide mal-practices in Sri Lanka (Bandara, 1987; Jayathilake and Bandara, 1988, 1989; Sivayoganathan, 1990) and the consequent number of poisoning cases (Jeyaratnam *et al.*, 1982; Jeyaratnam *et al.*, 1987; Jeyaratnam, 1990; Senanayake and Karalliyadde, 1986), though the majority is suicidal in nature (Jeyaratnam *et al.*, 1982). Nevertheless the message had come across that there is a need to safeguard the health of the people and this has indeed become one of the gravest concerns of the Registration Authority.

**Table 2.**
**Pesticide consumption in Sri Lanka 1995-2000**

| Pesticide Category | *Quantity of Active Ingredient (mt)* | | | | | |
|---|---|---|---|---|---|---|
| | *Year* | | | | | |
| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
| ***Insecticides*** | | | | | | |
| Chlorinated hydrocarbons | 48.30* | 50.67** | 45.86** | 37.16** | 12.44** | - |
| Organophophates | 202.00 | 155.93 | 214.13 | 184.51 | 327.29 | 232.59 |
| Carbamates | 77.31 | 63.57 | 66.09 | 116.94 | 55.15 | 112.40 |
| Pyrethroids | 0.46 | 1.53 | 0.71 | 0.77 | 1.05 | 0.81 |
| Botanical products and biologicals | - | - | - | 0.0056 | 0.0079 | 0.0062 |
| Insect growth regulators | 0.27 | 0.27 | 0.83 | 2.76 | 2.23 | 2.55 |
| Others | 96.58 | 99.86 | 23.38 | 31.88 | 15.90 | 29.36 |
| **Total Insecticides** | **424.92** | **371.83** | **351.00** | **374.03** | **414.07** | **377.72** |
| ***Weedicides*** | | | | | | |
| Phenoxy hormone products | 189.45 | 164.52 | 240.05 | 215.95 | 261.76 | 168.32 |
| Triazines | 0.82 | 0.54 | 0.56 | 0.31 | 0.45 | 0.56 |
| Amides | 443.72 | 402.20 | 391.88 | 341.48 | 313.23 | 302.72 |
| Carbamates-Herbicides | - | - | 21.49 | - | 13.79 | - |
| Urea derivatives | 31.62 | 20.10 | 36.70 | 23.06 | 20.82 | 23.03 |
| Bipiridils | 54.49 | 63.92 | 16.12 | 67.12 | 82.69 | 74.27 |
| Others | 95.13 | 121.36 | 157.94 | 186.05 | 239.95 | 313.54 |
| **Total Weedicides** | **815.23** | **772.64** | **864.74** | **833.97** | **932.69** | **882.44** |
| ***Fungicides*** | | | | | | |
| Inorganics | 182.22 | 193.81 | 168.23 | 171.83 | 180.35 | 172.65 |
| Dithiocarbamates | 265.17 | 222.84 | 201.61 | 124.16 | 205.32 | 236.48 |
| Benzimidazoles | 4.92 | 3.84 | 5.54 | 5.85 | 8.20 | 7.82 |
| Triazoles, Diazoles | - | - | 1.53 | 0.27 | 2.70 | 1.57 |
| Diazines, Morpholines | 2.65 | 2.50 | 2.50 | 2.85 | 2.35 | 2.20 |
| Others | 40.52 | 86.05 | 25.00 | 19.22 | 21.13 | 14.76 |
| **Total Fungicides** | **495.48** | **509.49** | **404.41** | **324.18** | **420.05** | **435.48** |

Note: Pesticide classification is based on the "List of Major Plant Protection Products", FAO Statistics Division, Rome, Italy.
* Values are based on the consumption of chlordane and endosulfan.
** Values are based on the consumption of endosulfan only.

Surveys have revealed that vegetable cultivators are generally not aware of good agricultural practices and normally apply more than the recommended dose of pesticides (Jayathilake and Bandara, 1988). Excessive use of pesticides has been reported to have long term adverse effects on the immediate environment. A survey on impact of agriculture on ground water quality carried out at Kalpitiya peninsula where onion is cultivated extensively has revealed significant levels of carbofuran and very high levels of nitrate fertilizers in groundwater (BGS, CISIR, and Department of Agriculture, 1992). In addition, precautions like pre-harvest intervals are often not followed leading to potential residue problems. The risk of human health from pesticide residues is due to the pesticide residues in the edible part of crops and the daily consumption of crops. Although, persistent products are screened out during registration and pre-harvest intervals are given accordingly for the recommended crops in the label, the common farmer practice of applying pesticides close to harvest and sometimes even after harvesting for protection during transport and marketing do raise concerns of high levels of residues in foods.

Aside from vegetables, indiscriminate use of pesticides in tea can cause residue problems and the consequent repercussions in international trade. Though Sri Lanka has been acclaimed as having the cleanest and best tea in the world with respect to pesticides, there were instances where pesticide residues have been detected in the exported consignments. A study conducted by M.P. de Silva and W. Thiemann in 1991 has found detectable levels of DDT, cyclodienes and lindane in tea grown in up-country, though the use of these chemicals have been banned for almost two decades. It is speculated that the residues may have been originated at the cultivation stage of tea. Development of pest resistance has become a serious concern so much so that in anticipation of such, led the authorities to direct that use of new generation synthetic pyrethroids in particular be restricted.

***Sustainability of synthetic pyrethroids***

The Pesticide Registration Authority had reviewed the subject of the use of synthetic pyrethroids for the control agricultural pests as early as 1985. Based on the reports (IRRI, 1976; Elliot *et al.*, 1978) following conclusions were made:

1. Continued use usually causing a high destruction of beneficial parasites and predators in the crop environment.
2. Presenting strong evidence of the progressive development of pesticide resistance of even a higher order than caused by organochlorine pesticides like DDT.
3. Some evidence of stimulating effects on reproductive features resulting in the resurgence of certain pest species like the Brown Plant Hopper (BPH) of rice.

All these features suggested that a very strict control should be exercised in the employment of insecticides in this group stating that it would be best to debar pyrethroid use in agricultural crops except for those pests (control of onion caterpillar in onions and pod/stem borer in brinjal) specifically recommended by the Department of Agriculture for which limited quota for each registrant was permitted totaling 11,700 liters per annum.

Considerable evidence that appeared over many years indicates that routine pesticide use can cause pest and vector outbreaks, upset of natural eco-system (due to their effects on non-target organisms), environmental pollution and harm on human health and the wildlife. Scattered incidences

**Table - 3**
**List of banned pesticides in Sri Lanka**

| *Pesticide (CAS Registration Number)* | *Local Regulatory Decision* |
|---|---|
| 2,4,5-T(93-76-5) | Banned in September 17, 1984 |
| aldicarb(116-06-3) | De-registered in 1990 |
| aldrin(309-00-2) | All crop uses prohibited in August 01, 1986. No remaining uses allowed |
| arsenic (arsenites and arsenates)(7440-38-2) | Banned for Agricultural use in February 03, 1988. |
| atrazine(1912-24-9)binapacryl(485-31-4) | De-registered in 1994.No history of use. No chance of registration. |
| bromacil(314-40-9) | No history of use. No chance of registration. |
| captafol(2425-06-1) | Banned in January 26, 1989 |
| chlordane(57-74-9) | Banned in January 01, 1996 |
| chlordimeform(6164-98-3) | Withdrawn from the market prior to 1980. No chance of registration. |
| chlorobenzilate(510-15-6) | No history of use. No chance of registration |
| DDT(50-29-3) | Banned for agricultural use in 1970. Phased out from vector control in 1976. |
| dichloropropane(542-75-6) | Banned in January 01, 1990 |
| dibromochloropropane (DBCP)(96-12-8) | No history of use. No chance of registration. |
| dieldrin(60-57-1) | Agricultural uses prohibited prior to 1980. No remaining uses allowed. |
| dinoseb / dinoseb salts(88-87-7) | No history of use. No chance of registration. |
| endosulfan(115-29-7)endrin(72-20-8) | Banned in December 31, 1997. Prohibited prior to 1970. |
| ethylenedibromide (EDB)(106-93-4) | No history of use. No chance of registration. |
| ethylenedichloride(107-06-2) | No history of use as a pesticide. No chance of registration. |
| ethyl parathion(56-38-2) | Banned in November 19, 1984 |
| ethylene oxide(75-21-8) | No history use. No chance of registration. |
| fluoroacetamide(640-19-7) | No history of use. No chance of registration. |
| HCH (mixed isomers)(608-73-1) | Banned in October 09, 1987 |
| heptachlor(76-44-8) | Banned in January 27, 1988 |
| hexachlorobenzene (HCB)(118-74-1) | No history of use. No chance of registration. |
| leptophos(21609-90-5) | Banned in January 27, 1988 |
| lindane(58-89-9) | All crop uses prohibited in August 01, 1986 except for treatment of coconut nurseries and emergency use for spotted locust control. No remaining uses allowed. |
| mercury compounds<br>mercuric chloride (7487-94-7)<br>mercuric oxide (21908-53-2)<br>mercury (7439-97-6)<br>mercury chloride (7546-30-7) | Banned in June 30, 1987 from agricultural use. No remaining uses allowed. |
| methamidophos(10265-92-6) | Banned in January 01, 1995 |
| maleic hdrazide(123-33-1) | No history of use. No chance of registration. |
| methyl parathion(298-00-0) | Banned in November 19, 1984 |
| mirex(2385-85-5) | No history of use. No chance of registration. |
| pentachlorophenol(87-86-5) | Withdrawn from the market in 1994. All uses prohibited. |
| phosphamidon(13171-21-6) | Withdrawn from the market. All uses prohibited. |
| quintozene (PCNB)(82-68-8) | Banned June 01, 1990 |
| toxaphene (camphechlor)(8001-35-2) | No history of use. No chance of registration. |
| thalium sulphate(7446-18-6) | Withdrawn from the market prior to 1980. All uses prohibited. |

are reported on deaths of peacocks and other kinds due to the consumption of rice grains that has been treated with insecticides. The misconception that chemical pesticides are the lasting solution in eliminating pests and vectors of diseases has led to routine and injudicious use of pesticides. With pesticides becoming less effective, users tend to increase the dose and the number of pesticide applications or by making or changing to un-recommended products. The pest problem is further aggravated by the build-up of resistant populations and the loss of natural enemies of the target pests formerly associated with agricultural cropland. A classic example is the change in status of the leafroller of rice which was the minor pest in the past (Nugaliyadde *et al.*, 2001) due to unscrupulous spraying of broad spectrum insecticides in rice fields. Quite often changes also occur in the pest composition of a crop. The increase in pesticide use leads to increased input costs, and decline in income with the results that uncontrolled pests and vectors impacting more on crops and on human and animal health. Thus, cultivation becomes uneconomical and may result in the farmers totally abandon it.

Current actions and policies are in effect to prevent the escalation of the many undesirable effects that have resulted from the dependency on pesticides. These have been primarily technical, educative, and legislative. The Department of Agriculture's policy over the last several decades has been to phase out reliance on pesticides for food production by adoption of integrated pest management technologies such as breeding for resistance, etc.

**Specific approaches over risk reduction, safe use of pesticides**

The registration scheme of Sri Lanka is tailored in a realistic approach to meet the country's needs with the limited resources of scientific expertise and support facilities available to the Registration Authority. No pesticide, even for experimental purposes can be imported without the approval of the Registrar of Pesticides. Depending on the need, an experimental clearance may be granted, subject to submission of chemical identity, toxicology and bio-efficacy data. The full data package is required for the assessment of safety of coded products (which are in the initial stage of development or pre-market development stage), *i.e.* to verify whether the benefits overweigh any potential hazards.

Easy accessibility, high lethality of substances and irresponsible handling of pesticides are some of the factors associated with the high rates of pesticide related incidences. Suicides in Sri Lanka has been claimed to be one of the highest in the world (47 per 100,000 in 1995) over the past several years (Police Data on Suicides, 1998) and suicides account for more than 80% of the total pesticide poisoning in Sri Lanka. But, the accidents and occupational exposure are far less reported than anticipated when compared to the suicide statistics, mainly because of the differential administrative approaches in case of poisoning and comparatively low mortality rate in accidents. Senanayake *et al* conducted a research on neurotoxic effect of organophosphorus insecticides, and observed secondary effects, which have not been recorded earlier. Current information from field studies (Jayathilake and Bandara, 1988; Jeyaratnam and Ponnambalam, 1980) revealed that the highest risk to humans arises from skin and respiratory exposure due to spray applicators not using protective clothing.

Based on past evidence, a modification of the registration procedure was practiced to expedite the registration of safer alternatives with the gradual phasing out of highly hazardous pesticides (*viz*; monocrotophos, methamidophos, etc.). A 25% import cut back based on the previous year import volume had been placed on the highly hazardous pesticides since 1990. But to contend with the pest problems faced by the farmers, alternates had to be processed expeditiously. Therefore, a policy decision was made to entertain registration applications without local bio-efficacy testing (which generally requires a minimum of two years) provided their use had been officially recommended in countries having similar cropping patterns and pest species. Further enforcement of the Act was practiced to make hazardous pesticides much less easily available for abuse. As a result, retailing them in the smaller pack sizes of 50 ml, which had been identified as a favorite "suicide pack" was prohibited.

With the advent of the Department of Agriculture policy for safer and judicious use of pesticides for crop protection, all pre-registration bio-efficacy testing of pesticides were undertaken only for less hazardous, or reduced environmental burden, or target specific products cleared by the Registrar of Pesticides after an initial review of a limited set of data to evaluate for potential risks to human and the environment.

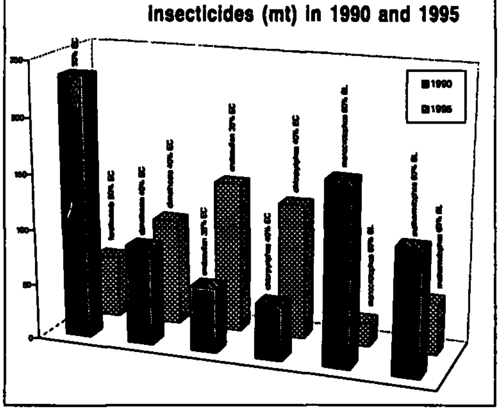
**Basis for the assessment of acute risk to health**

The World Health Organization (WHO) of the United Nations has recommended a hazard based classification scheme for pesticides (WHO, 1989). This classification is based primarily on the lethal dose administered orally or dermaly, which cause 50% mortality in the rat since these determinations are standard procedures in toxicology. Thus, certain pesticides are classified as "Class I hazard categories" ($LD_{50} \leq 200$) depending upon their scientifically determined "$LD_{50}$ Value"[1]

This basis for risk (acute risk to human health) assessment of pesticides is the WHO hazard classification which is based on oral and dermal toxicity of the technical material. Technical material could contain around 94-99% of active ingredient, depending on the manufacturing process. The balance that is 1-6% may contain water, solvents, and other impurities. Some impurities in technical grade material have a higher level of toxicity than that of the active ingredient. Thus, not only has the Registration Authority to be concerned with the toxicity of technical grade *per se* but also the toxic impurities which vary with the manufacturing process. In the case of 94% technical grade chlorpyriphos, toxic impurity sulfotep would be hazardous if it is above 0.3% which would result respective chlorpyriphos 40% Emulsifiable Concentrate (EC) formulations in the Class Ib (acute oral $LD_{50}$ is within 20-200 mg/kg in liquid base) categorization.

Toxic impurities occur in malathion, which is one of the widely used insecticides (175 metric tones of Malathion 50% Wettable Powder (WP) were used in 1996) in anti malarial activities. In a survey done in Pakistan (Baker, 1978) among 7500 field workers engaged in malaria control showed poisoning due to certain formulations of malathion having high levels of isomalathion as a result of production problems in the technical grade material and poor storage. In 1993, a consignment imported had unacceptable isomalathion levels. The detection was made as prior to release of the product. These issues have prompted the Registration Authority to institute strategies for quality assurance, and mandated "...as proof of quality, malathion products offered

**Figure 1: Annual consumption of insecticides (mt) in 1990 and 1995**



should be registered nationally (in the country of origin) or internationally".

As cautioned by the WHO (1998) in para "... it should not be overlooked that in formulations of technical products, solvents or vehicles may present a greater hazard than the actual pesticide. ***It is by far preferable that the final classification of a formulation should be based on toxicity data obtained on that formulation***". Pesticide formulations contain solvents, emulsifiers, coloring agents, etc., and some of them have been identified as enhancing the toxicity of the formulation. Therefore, to elucidate the toxicity of a formulation, risk evaluations should not be extrapolated on the basis of the percentage of technical grade material in the formulation alone but on the full toxicological information of the formulation.

After the policy decision to prohibit the import and use of Class Ib products locally, registrants are required to submit toxicity data on formulations. Two cases have been detected where false toxicity data have been submitted. These were formulations of 35% EC endosulfan and 20% EC carbosulfan from new sources after the patent held by the original manufacturer had lapsed. The supporting toxicity data submitted by the applicant in contradiction to data submitted by the original manufacturer and formulator identify similar formulations to be Class II products. As a means of confirming the data and credentials of the new source, the services of independent laboratories have been employed and revealed their falsity. Sources revealed that susceptibility to some insecticides (*i.e.* endosulfan) varied between male and female rats (normally by a factors of approximately 1:5), phenomenon that has been taken into account in the WHO Guidelines to Classification of Pesticides by Hazard (WHO, 1998). As an outcome of this experience, to reduce potential hazards to health to users, toxicity data on formulations with $LD_{50}$ less than 200 mg/kg are strictly cross-checked prior to registration.

The above speaks of how pesticide regulation has had a direct impact on human health by reducing potential hazards to workers in pesticide formulation and re-packing units and to pesticide applicators in the field.

**Assessment of chronic health concerns**

For registration purposes, the toxicological data required not only data from acute studies which provide information on the health hazards likely to arise soon after or as a result of short-term exposure to a pesticide but also data on sub-chronic studies to provide information on health hazards that may arise from repeated exposure over a limited period of time and data on chronic studies which would indicate health effects following prolonged and repeated exposures. Due to resource constraints, for more complex short and long-term toxicological and environmental impact assessments, heavy reliance is placed on scientific conclusions drawn by developed countries.

The Pesticide Registration Authority had received and reviewed a number of studies on atrazine, most of that were required of the registrant as of supporting post-registration evaluations. Atrazine was one of the most widely used weedicides in sugarcane. Atrazine had been identified as a potential surface and groundwater contaminant due to its persistence and mobility in sub-soils. A local study conducted by Wettasinghe and Pieris (1998) confirmed that atrazine persisted more than 6 months in Reddish Brown Earth (RBE) soils, where most sugarcane cultivation were exist, providing definitive conclusions for surface and groundwater contamination. Long persistence led Registration Authority to de-register atrazine containing products in 1994.

The use of benomyl in Sri Lanka has been severely restricted in 2000 in the light of adverse health and environmental reports (WHO, 1994; EXTOXNET, 1998) and the restrictions placed on the product by some other countries (UNEP/IRPTC, 1996). It was a fact that the benomyl has been widely used for post-harvest treatments especially in fruit sector. Further, it was considered the fact that the majority of farmers and pesticide users generally do not abide by the recommendations and often overuse with little precautions, increasing the potential risk of high level of exposure to the applicators as well as the consumer of treated crops. Therefore, in spite of the fact that there had been no credential reports available on the local use pattern and food contamination, a regulatory decision was taken to severely restrict benomyl products in Sri Lanka, considering the worst-case scenario in the interest of the public and the environment.

Apart from the inherent toxicity of pesticidal substances, the hazard of the final market product is greatly dependent upon the impurities, which may arise as by-products during manufacturing as well as degradation products under poor storage. The still ongoing "Agent Orange" controversy centers on the use of dioxin (2,3,7,8-TCDD) contaminated weedicide 2,4,5-T during Vietnam War (from 1962 to 1971) and the resultant health problems linked to wartime exposure of the population to the contaminant (Colborn *et al.*, 1997).

Ethylene thiourea (ETU), an impurity in the most extensively used class of fungicides is a potent carcinogen. FAO (1980) has set a maximum allowable impurity level of 0.5% for ETU in ethylenebisdithiocarbamates (EBDCs), *i.e.*, mancozeb, maneb, zineb. Under careful control manufacturing procedures the levels of these dangerous impurities can be maintained below the harmful levels. While long-term chronic toxicity data evaluations enable the identification of products that could cause carcinogenic, embryotoxic or teratogenic effects, information on toxic impurities identified as having chronic health concerns are currently being monitored by the Registration Authority.

Solvents too enhance toxicity of formulations. Isophorone (used as a solvent) in the formulations of propanil could be hazardous to handlers as it has been listed as a toxic inert causing neurotoxicological and other chronic effects of humans (US EPA, 1989). With a view to safeguarding factory workers engaged in re-packing and pesticide applications, a policy decision was made to de-register all propanil formulations containing over 40% isophorone in Sri Lanka. Certain coloring agents (*viz.*, Malachite Green), emulsifiers (*viz.*, dimethy lformamide) and stabilizers (*viz.*, propylene oxide) used in pesticide formulations have high toxicological concerns. In fact, the toxicity of solvents and other adjuvants in pesticide formulations offered for registration are also evaluated in the registration process and are periodically reviewed.

The regulatory input to contend with the above problems is to promote safer formulations and safer active ingredients. This applies both to replacement of the more hazardous Emulsifiable Concentrations (EC), Wettable Powders (WP) with comparatively less hazardous formulations such as Suspension Concentrations (SC), Water Dispersible Microgranules (WG), Capsule Suspensions (CS), etc., and promoting the registration of Insect Growth Regulators (IGRs) which target specific sites in insects which are not common to mammals. However, there is a growing concern among scientists that these insect growth regulating compounds disrupt normal molting processes, limb generation, and reproduction in arthropods (Cunningham, 1976; Touart and Rao, 1987; Forward and Costlow, 1978) too could have adverse impacts on ecologically important spiders, crustaceans, etc. Invertebrates are ubiquitous, represent over 95% of all animals, and are tremendously important ecologically and economically. Commercial fisheries of shrimp, crab, and lobsters and agriculturally important insect pollinators (*viz.*, bees) are few key species. Juvenile hormone mimics (*e.g.*, pyriproxyfen), chitin synthesis inhibitors (*e.g.*,

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chlorfluazuron, buprofezin, lufenuron) and ecdyson analogs (*e.g.*, tebufenozide) are examples for some Insect Growth Regulators currently registered for use. However, the end use of such products would of necessity be carefully checked so that, adverse side effects on related species (arthropods) would be minimum, before licensing with restrictions.

**Impact of pesticide bans and use restrictions**

The adverse effects that pesticide use causes on the environment, human and animal health justify the Registration Authority to put regulations in place to govern importation, distribution, sale, storage and use. Banning the use of certain hazardous pesticides is a way of prohibiting importation and therefore, avoiding the use of environmentally persistent pesticides like DDT, aldrin, dieldrin, chlordane, and lindane.

The majority of countries in the region have banned some pesticides due to their adverse effects on the environment, human and animal health while putting some other pesticides on a list of restricted use because of the absence of effective alternatives. Countries with working pesticide registration schemes often review registrations in terms of efficacy, impact on the lifeforms and the environment. On the basis of new information arising from properties of the product, reviews may result in banning or restricting the use of certain pesticides. The impact of banning some pesticides while restricting the use of others has not been assessed in majority of countries. However, the immediate effect observed is the shift towards the utilization commodity type alternatives. This situation was observed with the phase-out of monocrotophos and methamidophos where there was a clear trend towards the use of less expensive, broad-spectrum, commodity type pesticides such as chlorpyriphos, endosulfan and dimethoate (**Figure 1**). If the need is to reduce the use of pesticides, the main options available can be broadly classified into restriction of availability through regulatory measures and offering a package with alternatives to the user of pesticides such as Integrated Pest Management (IPM), Organic Farming, etc. It was evident as illustrated in the **Figure 1** that if the farmer is not given an alternative option, they simply switch to another pesticide but no significant impact on the total use. But, if a promotional package is offered we can anticipate a reduction of use of pesticides or a deviation from the trend in chemical dependent pest control. The significant reduction in the use of fenobucarb (BPMC) in 1995 compared to that of 1990 (**Figure 1**) may be a result of intensive rice IPM program conducted by the Department of Agriculture where fenobucarb is mainly used on rice Brown Plant Hopper (BPH) control.

**The Sri Lanka Banned Pesticide List (BPL)**

The Sri Lanka Banned Pesticide List (BPL) is a list of pesticides (**Table 3**) that have been reviewed and decided by final regulatory action to phased-out from use in the country as they pose unreasonable risks to human health and the environment based on the scientific studies conducted related to the pesticide which shows carcinogenecity, mutagenecity, teratogenecity, persistence, bio-accumulation, etc.

Many of the decisions have been made possible because of the linkages established with international and local regulatory authorities of foreign countries. Information received from such sources results in review of products as an ongoing function of the regulation.

***Footnotes***

[1] The $LD_{50}$ value is a statistical estimate based on the acute oral and dermal toxicity expressed by the mg of toxicant per kg of bodyweight required to kill 50% of a large population of test animals (usually rats).