TOXIC SUBSTANCES AND HEALTH

CHEMICALIZATION OF DEVELOPING COUNTRIES.

It has been estimated recently[1] that in the less developed countries two thirds of the inhabitants are exposed to chemicals which may prove harmful to their health. Furthermore, exposure to these chemicals - 80% of which are manufactured in industrialized countries - will undoubtedly rise in the future. A case in point is the pesticides which are used to control disease vectors and crop pests. World pesticide sales grew from 8.1 billion US dollars in 1972 to 12.8 billion US dollars in 1983, with the most rapid growth occuring in the developing countries[2]. This rapid growth can be measured by the cost of exportation of various chemicals to LDCs which rose six-and-half fold in the 1970-80 decade. As some 15,000 individual compounds and more than 35,000 different formulations have come into use as pesticides since 1945[3], the magnitude of the potential health hazard can be appreciated.

In industrialized countries, the tightening of controling regulations has had the effect of moving the hazardous technologies to LDCs. There has been an increased export to Third World countries of chemicals banned at home because of their unacceptable toxicities. Thus, a significant portion of the pesticides used in the Third World are banned in the exporting countries. For example, 20% of the pesticides exported from the USA have had their registration for use in the US cancelled or

suspended by that government because of their toxicity to humans or to the environment[2]. However, it can be expected that these technology transfers involving the use of highly toxic chemicals will continue to happen at an increasing rate. Indeed, development imperatives in all LDCs, more so in the emerging countries, will continue to mean increased industrialization and agroindustrial exploitation. The concomitant need for labour will regretably signify that more ill-trained workers will find employment in industries where they will face dangerous processes and chemicals. In many instances, the unsafe working conditions will be compounded by the workers' unwillingness to obey safety procedures because cultural biases and lack of knowledge will cause them to disregard safety protocols. The absence of stringent regulations for the use of hazardous chemicals in industry and agriculture in most countries of the third world, allied to the rightful industrialization imperative of developing nations can spell wholesale disaster because of the lack of appropriate knowledge. Recent chemical disasters in Mexico and Bhopal -- to cite extreme examples -- have shown that this transfer of hazardous technologies from North to South does not solely affect the workers involved with these processes, but poses a major public health risk to surrounding communities.

PESTICIDES

Without pesticides, dramatic loss of crops, especially in the tropics, would have exacerbated the existing food shortages

immensely. As well, the use of these chemicals was instrumental in the past for the radical decrease of some vector-borne diseases. It should be remembered that the majority of the 10,000 principal insect pests species and 600 weed species which curb food production are found in the third world[20]. Notwithstanding the importance of pesticides in the control of agricultural pests and past success in controling diseases such as malaria, pesticide overuse has now started to erode these original benefits. This is mainly due to the appearance of resistant pest species. Indeed, it has been suggested that every kg of DDT (an organochloride insecticide) sprayed on cotton fields in Central America accounts for 105 extra cases of malaria following the appearance of resistant strains of non-target organisms such as anopheline Mosquitoes[6]. Pesticides are by nature toxic to all living things, a fact that users are learning the hard way. To cite the Bhopal Working Group of the APHA[26], "*Pesticides are poisons by design*".

In 1972, the World Health Organization estimated from the published statistics of 19 countries that there were as many as 500,000 cases of pesticide poisoning cases per year. However, according to a recent publication[4]:

> *"In 1977, based on notifications from several governments and surveys of nine countries, WHO estimated that the number of deaths globally was about 20,640 a year. In 1981, OXFAM, up-dating*

the WHO figures, estimated that world pesticide-related poisonings were around 750,000 a year. More recently, the Economic and Social Commission of Asia and the Pacific (ESCAP) suggested that pesticide poisoning incidents might amount to two million a year, of which 40,000 could be fatalities."

There is now a growing concern about the toxic effects of pesticides to humans and domestic animals in developing countries. However, the orthodox research establishment is mainly directing its activities to occupational exposure, more specifically of those workers involved with the spraying or direct handling of these chemicals. In most cases, only acute, obvious cases (classic symptomatology) are consigned to medical records.

However, researchers are now increasingly aware of underreporting. For example, Loevinsohn[5] found an association between occupational exposure to pesticides and an increased mortality from non-traumatic causes in the Central Luzon province of the Philippines. The increased mortality (27%) was correlated with those conditions, such as stroke often associated with (or likely to be confused with) pesticide poisoning . This is a clear warning that the actual incidence of pesticide -- or toxic chemical -- related deaths may to date have been grossly underestimated, not only for lack of proper records but possibly also because attending physicians and health practitioners may

fail to recognize the symptoms of pesticide poisoning.

The toxicity of pesticidal compounds should surprise no one: Parathion, one of the early organophosphates synthesized and characterized for its anticholinesterase effects, was the parent compound for a series of nerve gases investigated during World War II for possible use as antipersonnel weapons. Parathion is still in use in many countries as an insecticide.

The molecular basis of action of organophosphates on nerve transmission has been extremely well studied[7], and one would have thought that all observed effects in the field could be ascribed to this mechanism. However in recent years -- doubtlessly because the wholesale use of these pesticides has transformed the fields of the third world into a toxicology laboratory -- clinical effects which cannot easily be ascribed to the classic anti-cholinesterase action of these chemicals are emerging. First, reports of a delayed polyneuropathy appeared in the literature[8], and more recently the description of an *intermediate organophosphate poisoning syndrome* was published[9]. This syndrome involves the paralysis of a number of muscle sets including the respiratory muscles, and which has resulted in the death of a number of patients. It is also distinct from the well defined cholinergic phase which characterizes the normal acute cases of poisonings.

The prevalence of these two *new* syndromes is yet to be

evaluated anywhere in the world in relation to declared cases of pesticide poisonings. It may well be that numerous patients released from health centres following the treatment of the acute cholinergic phase of organophosphate poisoning suffer and die from these syndromes unbeknownst to the treating physician. There are also recurrent reports of psychological after-effects of organophosphate poisonings, relating to impaired concentration, increased distraction as well as continued visual disturbances, headaches and nervousness even three years after the incident[10].

The particular conditions prevalent in the Third World can significantly aggravate the effects of pesticide intoxication. The state of individuals' health may strongly influence their sensitivity to chemical poisoning. No studies have yet been conducted in rural Third World countries proving that states such as chronic malnutrition do indeed aggravate the chemical risk. Laboratory studies[12], however, have shown that rats maintained in a state of dietary protein deficiency were more susceptible to the alteration of hepatic enzyme activities following the administration of Malathion (an organophosphate). Decreased liver protein and lipid contents were also observed. The state of malnutrition prevalent in Third World populations could therefore bring about an increased susceptibility to intoxication, especially in women and children.

The evolution of agricultural practices now encourages the large scale use of herbicides to control weeds and to dessicate

some crops prior to harvesting. These compounds are highly toxic. Reports of their carcinogenicity are now being published regularly, especially in connection with phenoxyacetic acids such as 2,4,D[11,12]. The importance of intoxications to one herbicide - Paraquat - was exemplified by Mahathevan[14]: from 1977 to 1981, *post-mortem* analysis of pesticide - linked deaths were performed in Malaysia. Out of 569 cases studied 326 detections of herbicides were made, 310 of them Paraquat.

Responsive to the particular threat posed by this herbicide, the Health Sciences Division is supporting a study in Colombia (Paraquat Intoxication [3-P-84-0279]). Preliminary results indicate that paraquat intoxication is not seen in individuals who are not directly involved with spraying the compound, although its presence in the environment appears to be ubiquitous.

The survey of a subsample of sprayers is now underway to confirm the occupational nature of Paraquat intoxication, but it would appear that in the Colombian setting at least, pesticide poisonings are mostly related to occupational exposure. Other, larger studies in Asia indicate that the major proportion of reported cases of pesticide poisonings is either suicidal or criminal[15].

The latter findings agree with those of an IDRC sponsored study carried out in four south-east Asian countries (they were Sri Lanka, Indonesia, Thailand and Malaysia, [3-P-83-0089]). The

findings are, however, contrary to recent reports from Latin America other than the previously cited example.

In Costa Rica, for instance, 6.4% of pesticide poisonings were suicidal, while 67.8% were occupational[16]. These contrasting data could either be due to cultural differences between these regions, or to differences in research methodologies!

Only after standardization of research protocols between researchers, and agreement on the terminology can we begin to have a true understanding of the prevailing situation in the LDCs regarding pesticide intoxications. *There is no doubt that IDRC can play an important role in this respect.*

Another aspect of the pesticide problem has been the persistence of some of these compounds in the environment because of their relative resistance to breakdown. This resistance is the major difficulty with organochloride pesticides, such as DDT, which are still used in some parts of the world to control disease vectors.

The danger this represents for humans, not to mention the rest of the biotic environment, is illustrated by a study performed by Atuma[17]. An analysis of multiple foodstuffs (domestic red meat, poultry, game, and vegetables) in Nigeria demonstrated the presence in all samples of organochloride pesticide residues. Organochlorides are very liposoluble and

readily find their way from the blood to mother's milk, therefore representing a grave risk for vulnerable nursing infants. This problem is further compounded by popular practices in many developing countries. In Zambia for example, it is reported that DDT is commonly used to protect dried fish from pest attacks[18].

Concerted efforts have been made to find and or sythesize new, less toxic (to non-target organisms) pesticides. Such an example is the Pyrethroids, a family of compounds originally isolated from Chrysanthemums. These insecticides were purported to exhibit a very low toxicity toward non-target organisms, specifically humans. They are neuroactive molecules, but their low dermal absorptive capacity was thought to render them safe for largescale use by even relatively untrained workers.

Nevertheless, severe cases of pyrethroid intoxication in sprayers of cotton fields in China were reported. In response, the Division is supporting a prevalence study of Fenvalerate intoxication (a synthetic pyrethrin derivative) in Hubei province, with a further investigation of the ethiology of the incidents (3-P-86-0083). Such occurences indicate clearly that pesticides are only as safe as the users allow, even in the case of less toxic compounds.

As such, it is becoming evident that the problem of chemical intoxications is in part an attitudinal one. This is true for end-users, but also true at higher levels. For example, Janzen[19]

(cited by Philogene[20]) reported in 1985 that the only countries in the African continent having a well structured and comprehensive system of importation and regulation of pesticide usage were South-Africa, Egypt, Mauritius and Zimbabwe. In other countries, this type of legislation is sketchy, nonexistent or imbedded in bodies of legislation indirectly related to pesticides.

Because of the lack of proper regulations, organochloride pesticides such as DDT, Dieldrin, Heptachlor, Aldrin, and BHC, banned in industrialized countries for their retention in the environment or their high toxicity are still commonly used in Zambia for example[18].

The setting down of appropriate legislation is rendered even more difficult by the lack of personnel in LDCs capable of making a toxicological assessment of imported pesticides and by the lack of proper laboratory facilities. Therefore, in most instances, countries will rely on toxicity studies carried out in industrialized countries, often by the producer. These safety evaluations of pesticides are usually based on studies performed in commercial toxicology laboratories[21].

In the late Seventies a number of developed countries (USA, Canada, Finland) started reexamining studies which had been submitted to gain registration of pesticides and found that a large proportion were invalid. This lead to the deregistration of many pesticides in these countries, because the manufacturers did

not substitute valid toxicity tests as requested[22,23]. The same invalid studies are nevertheless still being submitted to LDC governments by exporters, and still form the basis of the decision to import and in-country registrations.

LDCs make an increasing use of international aid subsidies to purchase pesticides[24], further aggravating the problem. Such subsidies allow Third World governments to sell pesticides to end-users at reduced cost, and encourage the use of these chemicals as the method of choice to increase crop yield. By the same token, they discourage farmers from making use of alternate methods of pest controls which rely less heavily on chemicals.

An other problem posed by the use and wholescale importation of pesticides has to do with the storage of these chemicals. Haynes[25] estimates that as much as 10% of pesticides may be wasted before they are applied, because of inappropriate storage practices.

In a study of storage conditions in four African nations, six south-east Asian countries and in Fiji, undesirable occurences -- such as pesticides stored near fertilizers, seeds, food or drink, lack of record keeping, absence of provisions for spills, lack of labels, corroded, leaking containers and improper repackaging -- were commonplace. The study indicated that most of the encountered problems might have been lessened if prior training had been available to shopkeepers/storage-facility handlers.

Corroborating this, the south-east Asia study supported by IDRC reports many instances of fatal poisonings in the home following the accidental ingestion of pesticide-contaminated meals. This was in most cases attributed to pesticides kept in unlabelled containers together with food in the cooking area.

It should be remembered that all pesticides , including those that are still in use in industrialized nations, are dangerous chemicals. As noted previously, 85% of the world pesticide production is used in industrialized countries, but it is estimated that the incidence of human poisoning may be thirteen times more important in the Third World than it is in the USA[27].

It is doubtful that this large difference can be accounted for solely by the higher toxicities of some of the compounds and formulations used in LDCs. One must therefore explore other causes.

A number of studies supported by the Centre indicate that end users are insufficiently, if at all, knowledgeable about the risks posed by pesticides and their misuse. Worse, farmers tend to shape their attitudes and practices on wrong information, leading in many instances to disastrous results to crops and humans alike.

In the majority of cases, pesticides are applied by workers using personal sprayers, for which only a few designs exist. To

the small landholder, a common model is the Lever Operated Knapsack sprayer (LOK sprayer).

Therefore, a considerable amount of interest has been generated in certain circles to design a safer, cheaper sprayer for use in tropical conditions. A recent workshop was organized in Kuala Lumpur (International Conference on Pesticides in Tropical Agriculture, September 1987), where this topic was discussed.

LOK sprayers were assessed in the Muda irrigation scheme in Malaysia by Anas *et al*[28]. They found that 20% of the 193 sprayers examined had serious faults or were badly damaged. The study also revealed that the farmers' knowledge with regards to the working and maintenance of the sprayers was seriously lacking.

Furthermore, a separate study indicated that farmers chose a particular brand of sprayer mainly for its weight, size, and ease and comfort of use[29]. Very little consideration was given to durability, safety, ease of repair and availability of spare parts. A recent review of LOK sprayers commissioned by the Centre [3-A-86-4075][30] outlined avenues of research deemed beneficial for the improvement of this technology, and recommended possible areas of involvement by IDRC.

It appears that aside from the inherent high toxicity of pesticides, another major cause of occupational and accidental

poisoning in LDCs could be the faulty technology allied to a grave lack of knowledge. User attitudes and practices must be changed through appropriate education, and sensibilization to the risks inherent to any inapropriately used technology.

Reports of such behaviour modification by users do exist even in the Third World. In China, it was shown that a proper prevention program was able to curb pesticide poisoning in a community. Community involvement was sought at all levels, from end users to government officials following a rash of very serious organophosphate intoxication[21]. The incidence rate decreased dramatically despite a marked increase in the use of pesticides by that particular community.

This report is encouraging. It means that prevention of pesticide poisoning is possible at the grass-roots, community level, possibly through simple education exercises and surveillance.

TOXICITY OF NATURAL CHEMICALS

The search for appropriate, affordable technology in the last few years has lead to the investigation of a number of locally occurring natural substances for various uses. In some instances, these are now the subject of major investments by commercial concerns. The synthetic pyrethrins mentioned previously are a good example.

In order to make the most of such natural compounds, however, one should encourage their use where they grow, in order to minimize the cost to communities. Some can be used directly, and others may need minimal processing by users or by cottage industries. Some plants have molluscicidal properties. This makes them ideally suited to control parasitic diseases for which snails are obligatory intermediate hosts; destroying the snails interrupts the transmission of the disease to humans.

Two molluscicides of plant origin, *Ambrosia maritima* (Damsissa) and *Phytolacca dodecandra* (Endod) have already shown great promise in laboratory and limited field testing. Studies have been supported by the Centre in Egypt: Bilharzia phases I to IV (3-P-76-0184, 3-P-80-0194, 3-P-82-0223 and 3-P-87-0204). However, toxicological and environmental impact studies to date have tended to be *ad hoc*. It is not possible to proceed to field and community testing of these products unless they are subjected to the same toxicological screening criteria as are synthetic pesticides.

A particular constraint to this has been the lack of plants and plant extracts of constant property (standard preparations)[32]. Unlike sythetic chemical pesticides, locally prepared water extracts of crude plant material will contain many additional and unknown substances, not to mention variable concentrations of the active ingredients. The fate of these compounds and their

metabolites in the environment will be difficult to assess reliably.

Hazards in applying plant molluscicides include pollution of water used for drinking, bathing and cooking, as well as accumulation of products in food and in the food chain, and the potentially toxic effects on non-target species such as fish on which the community may actually depend for nutrition.

A number of seed extracts have been used for generations in developing countries as flocculents capable of removing suspended solids from drinking/cooking water. Systematized research on these natural coagulants is being carried out by a number of organizations interested in appropriate, low cost technology for the benefit of Third World communities[24]. The Centre is no exception (Theythancottai water treatment [India, 3-P-84-0208]).

It is a fallacy, however, to think that these compounds are innocuous because they have been in use for generations. Tabacco is an excellent counterexample to that argument. Therefore, it behooves any organization supporting the study of natural coagulants to give serious thought to toxicity assesments when supporting research aimed at promoting the use of these chemicals.

In the case of coagulants, which are used specifically to treat water prior to its use for drinking or cooking, such studies are particularly appropriate . Here as in the case of pesticides,

one of the major hurdle might well be peoples' non-perception of the dangers inherent to the use of these substances.

OTHER CHEMICALS IN THE THIRD WORLD

Following the emphasis by LDCs of industrialization as a means to promote development, a large number of chemicals have now made their appearance in the Third World. Most of them are potentially toxic. The points made previously in regards to pesticides are essentially valid in the case of other chemicals in LDCs.

Apart from the fact that a considerable number of processes and chemicals in use in the Third World are now banned in industrialized nations because of their inacceptable toxicities, a number of other factors influence chemical risks in developing countries. In tropical environments, many chemicals react differently than they do in more temperate climes. More often than not, there are no available options for disposing of toxic chemicals, and neither are there appropriate technologies for handling and processing them.

Notwithstanding these more technical concerns, the major difficulties seem to lie with social and attitudinal problems. There is insufficient knowledge of the risk and proper handling of chemicals by workers, managers and health experts. Legislation on chemicals in the LDCs is inadequate; compounding the problem,

enforcement is rarely effective.

There are a number of major classes of toxic chemicals affecting the health of individuals in the Third World: heavy metals such as lead, arsenic, mercury and cadmium; certain chlorinated compounds other than the organochloride pesticides mentioned earlier, such as PCBs, TCDDs, PCDFs, and chlorinated phenols; and a large number of organic solvents which find their way into the industrial processes now being introduced in developing countries.

Many of these compounds are neurotoxic and oncogenic. Chronic exposure to threshold levels of these compounds may cause sub-acute sypmtoms not readily diagnosed as chemical poisonings. Cancers may also make their appearance 20 years or more after the initial exposures. The use of these chemicals is a reflection of the economic expediency of the industrial exploitation of natural ressources.

Some chemical toxicants are the product of the communities' activities, or even of the households'. A good measure of attention is now given in developing countries to indoor pollution, particularly in regard to women. Many housewives spend a large proportion of their waking hours toiling at or near the cooking fire.

Combustion is known to produce a large number of carcinogens

such as benzo-a-pyrenes. In locales where the customs are to cook indoors, this situation is worsened by the ubiquitousness of airborne particles, and of irritant gases such as NOx, CO and SOx. Information now emerging shows that chronic exposure to these airborne chemicals may in fact be partly responsible for some of the incidence of the acute respiratory infections (ARI) which constitute important and prevalent diseases in the Third World.

The geographic location of many cities and of their attending slums, together with certain atmospheric conditions often promotes the outdoor stagnation of cooking- and heating- fire emanations. Slums are often situated near the more industrialized sectors of third world cities. This is generally a reflection of the poor quality of life on these lands shuned by most well-to-do denizens. Factories are often operating without the benefits of the more sophisticated control technologies used in their developed world counterparts. This in turn means that in developing countries, a host of toxic byproducts are released unchecked in the living environment of nearby communities. The more common of these are the heavy metals which are produced by smelting, tanning, mining, etc. Conditions conducive to the the formation of a domestic smog will also favor the permanence in the surrounding air of these heavy metals.

What the inhabitants do not breathe-in directly, they will consume with their food and beverages on which these pollutants will soon settle. Considering the appaling hygienic habits common

to children the world over, one easily understands why they constitute a high risk group for heavy metal intoxication in this particular context.

Industrialized countries are partly to blame. For instance, many of hazardous chemicals reach the Third World with insufficiently documented toxicity data. For example,a week after the Bhopal incident -- just as had been the case for dioxin during the Seveso incident -- toxicologists were still frantically searching standard texts so that they could produce definitive medical statements in respect to methyl isocyanate[22]. A search of the literature at the time provided this reader with scant information, a fact much lamented by others[22]. Adequate data must be available to users if they are to assess the risks and provide their communities and individuals with sensible protection and aid in the case of incidents. The governments of the Third World cannot appropriately legislate the use of these chemicals in the absence of such information and without trained scientists capable of providing advice.

The existence of a lag time between the transfer of potentially hazardous industrial processes and that of the appropriate control technologies and regulatory procedures, is a most common occurence in LDCs. It is often the result of the application of a "double standard" of safety. However, the responsibility may not rest solely with the "exporter" of the technology.

In the case of the Bhopal tragedy, it was suggested that the cause of the incident might have included a number of factors: the failure of local operators to ensure standard operating practices and engineering controls; a slow withdrawal from the facility by the parent company; poor training; and some aspects of the policies and requirements of the Indian government[26]. The end result of these interactions was the exposure to an extremely toxic subtance, of an estimated 100,000 to 200,000 human beings, and the death of possibly 20,000 of them.

The issues concerned with toxic chemicals in LDCs in view of these countries' low degree of technological development are complex and difficult to resolve. Many of these chemicals are unquestionably necessary to bring about self-sufficiency in food production and economic development. On the other hand, the importation and application of many of the control measures necessary to safeguard the populations from the health risks inherent to hazardous processes and substances is extremely high. This often makes these protective technologies unaffordable to most LDCs.

AVENUES FOR RESEARCH

The preceeding brief overview does not cover all aspects of the chemicalization of LDCs. It only hints at the health hazards posed by toxic chemicals to often unsuspecting populations. By

design, the particular case of pesticides was accented because of their potential risk to rural populations, a group which still represents the largest portion of Third World inhabitants.

By looking at the situation in light of this review, a number of clear research opportunities present themselves. Many of them would be appropriate for IDRC support, and in many instances will need a multidivisional approach.

1) Baseline data - the existing situation.

From the published data, it is clear that the real extent of the incidence of chemical intoxications (particularly of pesticides intoxication) is still unknown, and badly underestimated. Therefore, there is a need for more prevalence studies to be undertaken in developing countries. The studies must address a number of crucial questions: what is the actual incidence of such poisoning cases, how does the particular physical and social environment affect this incidence, what pesticides are the most frequent culprits, and how is the incidence affected by the particular technology used in connection with these chemicals.

2) Basic understanding of the situation.

A number of hidden health effects have now been described such as delayed syndromes and misdiagnoses. Few rigorous studies of diseases with a late onset like cancer have been

undertaken as yet in developing countries to date.

It would be appropriate to support a small number of studies investigating the actual rate of underreporting in a given setting, the reasons for such under-reporting and even clinical descriptions of as yet undescribed symptomatology allowing researchers to estimate the true prevalence/incidence rates of pesticide intoxications.

Because pesticides have now been used in LDCs for more than 20 years, and because such a large population has been exposed to their effects, some retrospective cohort studies of cancers might be in order. In view of the large number of individuals exposed to potential carcinogens, environmental cancers may actually become major killers with serious implications for public health.

3) Information needs.

There is a dearth of information in developing countries on most aspects of toxic chemicals. In particular, the following needs present themselves:

a) 20 years after pesticides were introduced to the Third World, most health practitioners cannot recognize classic signs of pesticide poisoning, let alone the symptoms which are only now surfacing . There is a great need for diagnostic information to be collated and made available to health practitioners and communities.

This dissimination role is ideally suited to Poison Information Centres, and their establishment and strenghtening should continue. Linking with developed country institutions should be encouraged further. Operational research into the impact of these centres should be considered seriously. They should also be involved with the communities, providing education on the inherent dangers of all toxic chemicals leading to the prevention of such occurences.

b) Information must be made available to decision makers responsible for the importation of toxic chemicals. Poison Information centres can once again be a source of data which properly interpreted can form the basis of decisions to purchase and register. Operational research into the feasibility of such linkages should be explored. Furthermore, trained toxicologists are sorely lacking in LDCs. Only they can interpret toxicity data provided by exporting countries to recommend which substances should be imported and for which specific purposes. Through appropriate training, such individual could attain levels of proficiency allowing them to serve as consultants and to perform actual toxicity studies to validate incomplete or suspect toxicity data. Because of the research facet of these activities, training could be provided either through research activities or through provision of fellowships.

4) Regulating chemicals.

A number of issues related to chemical risk are directly linked to the lack of laws. Importation, registration, labelling, transport, storage and use of all chemicals, more specifically pesticides is often an *ad hoc* procedure. For example, the high proportion of reported suicides and criminal poisonings using pesticides might be linked to unregulated access to these highly toxic chemicals, and/or lack of enforcement. Therefore, research is badly needed into the social factors influencing importation, as well as all subsequent operations linked to pesticides in particular, and toxic chemicals in general. Information is needed on how decisions to purchase given chemicals are reached, which laws would best protect each country's inhabitants, and how prior training of operators could be enforced.

Operational research is needed in the establishment of efficient regulatory bodies, and evaluation of their impact on the number of poisoning cases and incidents is crucial.

5) Appropriate technology.

Attention must be given to appropriate technology, especially at the user end. For example:

a) Development of safe and efficient pesticide sprayers are a prime exemple of programs underway in some reputable

institutions of the Third World where the Centre's support could have a great impact.

b) The development and testing of appropriate protective clothing and gear adapted to tropical conditions are also projects that could be entrusted to Third World institution, and which could reduce the existing risk of toxic chemicals.

c) The local development of cheap but effective industrial control methods to insure the safety of hazardous processes should also be considered.

d) Operational research into alternate means of pest control in the field such as integrated pest management (IPM) should be encouraged. Such topics as biological control of pest species by natural predators, destruction of breeding grounds (vector borne diseases), investigation of natural pesticides such as bacteria and plant extracts (ENDOD & DAMSISSA) should be given more emphasis. However, great care should be exercised through appropriate toxicity studies to ensure that all natural substances used are not toxic to non-target species or to the environment.

6) Standardization of research methodology.

As mentioned previously, the lack of standardization in the terminology and methodology often makes it difficult to compare results from country to country. Such exercises should be encouraged whenever possible and practical.

Presently, an international workshop will be held to standardize a protocol to measure the incidence of poisoning episodes and their outcomes in developing country settings [3-A-87-]. It is planned that this protocol will serve in future projects involving the support of Poison Information Services. This will allow the validation of the methodology. Such workshops are desirable in other areas of research concerning toxic chemicals.

7) **Community perceptions and aspirations.**

Because the attitudes of community members will ultimately depend on their acceptance of new technologies and knowledge, research must invove them in the learning process. Most IDRC supported studies on pesticides have shown that the misconceptions and bad practices of farmers have always been instrumental in poisoning episodes. This type of study must continue, preferably in connection with prevalence studies. In that way, an understanding might be gained of the process of chemical intoxication in different settings of the Third World. Communities must be approached to gain an insight into the reasons poisonings occur: misconceptions, cultural bias toward a particular technology, lack of comprehension, lack of choice. All projects involved with the development of safe sprayers and of protective clothing are fated to fail if end users are not involved at every stage of the research.

8) Intoxications inherent to living conditions.

Projects should be supported on subjects such as the effect of indoor pollution on health. Valid, culturally acceptable solutions should be sought to this problem. They should be affordable to Third World families and easy to maintain or they will not be applied.

9) Ecological impact.

It should be noted that all environmental modifications will affect some, if not all, facets of the biotope. This will of course mean that humans, at the top of the food chain have the most to lose from negative aspects. Research is also needed to gain an insight into the long term effects on the environment of the introduction of many non-biodegradable chemicals such as organochlorides, and how they affect human health. Less obvious subjects that nevertheless merit our attention are the effects of these chemicals on the quality and productivity of food species which provide sustenance to developing country populations .

CONCLUSION

Most of the research topics outlined above are too broad in scope to be addressed easily, if at all, by one division's approaches. These topics will take on added significance when conducted by integrated multidisciplinary teams of researchers.

The Centre cannot do otherwise in the development of such projects. It is hoped that a dialogue which has started between HS, SS and AFNS in the form of a Pesticide Working Group will continue. It should evolve into a concerted effort across the Centre to develop multifaceted research projects which will produce significant information to improve the health and welfare of communities in developing countries.

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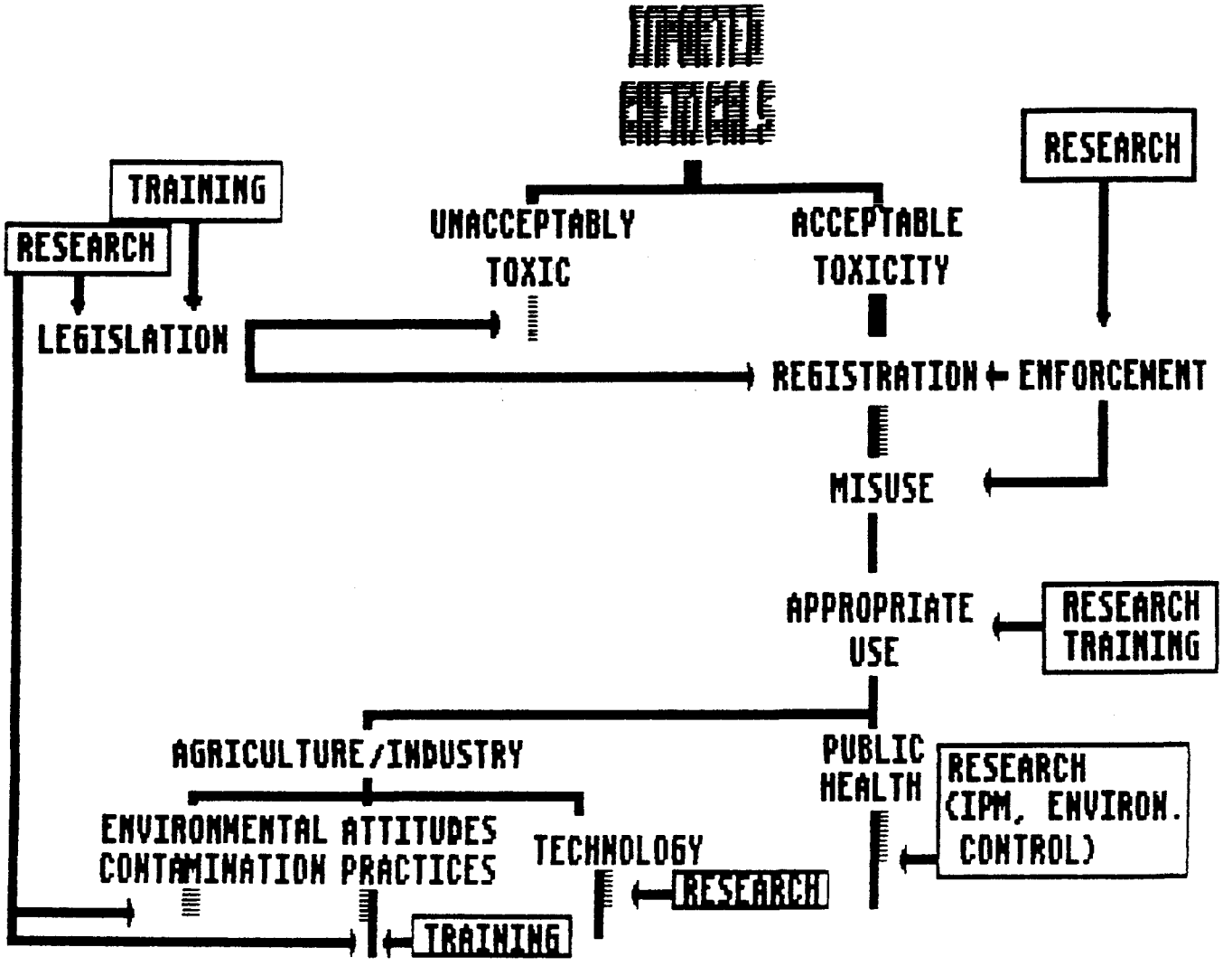

ANNEX I - RESEARCH OPPORTUNITIES AT DIFFERENT STEPS OF THE USE OF CHEMICALS IN LDCs.