FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

UNITED NATIONS
ENVIRONMENT PROGRAMME

IMPACT MONITORING OF RESIDUES FROM THE USE OF AGRICULTURAL PESTICIDES IN DEVELOPING COUNTRIES

Report of the FAO/UNEP Expert Consultation
held in Rome, 29 September to 3 October 1975

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IN DEVELOPING COUNTRIES"

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In accordance with Recommendation 8.2.3 of this Report, a selection of the papers considered by the Expert Consultation is being issued under the title:

Papers Before FAO/UNEP Expert Consultation on Impact Monitoring of Residues from the Use of Agricultural Pesticides in Developing Countries (FAO/AGP/1975/M/12)

CONTENTS

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1. INTRODUCTION

1.1 In opening this Expert Consultation, Dr. W.R. Furtick, Chief, Plant Protection Service, FAO welcomed the participants on behalf of the Directors-General of FAO and UNEP. He recalled that discussions on pesticides had featured strongly at the 1972 UN Conference on the Human Environment on which occasion FAO had been able to clarify its attitude. He drew attention to the fact that the FAO Position Paper drawn up for that conference in its conclusion had stated:

> "The provisions of facilities for investigating possible effects on the environment and to improve competence in measuring residues of pesticides in food, soil, water and other materials should be actively encouraged and supported, particularly in developing countries. By such means, it should be possible to monitor the occurrence of residues and to control any excesses at or near the points of use",

and he recorded his thanks that with support from UNEP it was possible to hold this meeting which represented a positive step towards meeting the quoted objectives.

1.2 Professor W.W. Kilgore was elected as Chairman and Dr. A.A. Agah as Vice-Chairman of the Meeting. Dr. C.A. Edwards was nominated as Rapporteur.

1.3 After some discussion on terminology, it was agreed that the term "impact monitoring", for the purposes of this programme, would be considered to cover any kind of physical, chemical or biological measurements in connection with known uses of pesticides, made with a view to obtaining information on the distribution of the chemical and/or effects in the environment.

1.4 The World Food Conference in 1974 recognised that, although much progress was being made in pest management systems and in the harmonious integration of chemical with non-chemical methods of pest control, considerable amounts of chemicals would be needed for controlling pests in agriculture for many years to come. It also noted that, although the total amounts of pesticides currently used in developing countries were relatively small, projections of future trends generally indicate heavy increases for such countries. Noting that these were the countries suffering most from the shortages in supplies prevailing at that time, the Conference recommended that steps should be taken to ensure that adequate supplies are made available to these countries on a continuing basis. At the same time and in view of the declared requirement of developing countries for well-established and inexpensive pesticides (which are mostly fairly persistent compounds) the Conference called for special efforts to avoid or minimise the problems, particularly environmental ones, that may arise from the projected increases in use.

FAO was asked to implement action on these recommendations in association with WHO, UNIDO, UNEP and other Agencies. In pursuance of this objective, the Ad Hoc Government Consultation on Pesticides, held in Rome in April 1975, was attended by representatives of 52 countries and of many other interested bodies. The Ad Hoc Government Consultation was preceded by a meeting of the FAO Committee of Experts on Pesticides in Agriculture in which representatives of other agencies participated. After reviewing the past and current programmes in plant protection, including programmes on integrated pest control and on pesticides, the Ad Hoc Consultation accepted that there was a need to raise levels of technical supervision, to increase training of advisory services and to take other steps designed to ensure maximum safety and efficacy in the use of pesticides. Its findings included recommendations that FAO's work relating to residues in foods and to the environmental impacts of agricultural pesticides should be supplemented. These included a proposal that a panel of Experts should be set up to advise and assist the Director-General on all matters related to pesticide residues and pesticides in the environment, with particular reference to:

> "Providing technical advice and support for the Organisation's activities designed to assist developing countries to determine residues of pesticides in their agricultural production; studying the occurrence and distribution of pesticides in the environment and their unintended effects; collecting, evaluating and interpreting information on the subject; providing technical advice and support for the Organisation's activities designed to assist developing countries generate and collect data on the occurrence and effect of pesticides in the environment; proposing international standards for environmental impact requirements".
>
> (Reference: Report of 9th Session of FAO Committee of Experts on Pesticides in Agriculture. AGP 1975/M/4)

The present Expert Consultation was pleased to note that FAO was planning to act on these recommendations and that the Panel of Experts would inter alia "stress the need for closest possible cooperation between the environmental interests of FAO, WHO, UNEP, and UNESCO to maximize the use of the limited resources for essential research and developmental work in this field" and would also "provide technical guidance on the subject to member countries". The proposal to set up this Panel, which would be formally constituted and provide a constantly available cadre of suitably qualified experts, was specially welcomed and its formation without delay was recommended by this Expert Consultation.

Regarding the organisation of an advisory panel of experts, a series of criteria were suggested that would be pertinent to the constitution of the panel:

(i) The panel should be to a maximum degree a multi-disciplinary body. Scientists should be sought with extensive experience in the laboratory and/or the field.

(ii) There should be representation of the different activities implicit in the development of the project, i.e., research, training, and administration.

(iii) Regional representation should not be a necessary requirement in the selection of individual members of the panel. However, the membership should possess direct experience in the regions under consideration, or familiarity with the conditions and potentialities to be encountered in such regions.

The Joint FAO/WHO Food Contamination Monitoring Programme which will collect data on the chemical and biological contamination of food, and the FAO/UNEP Cooperative Global Programme for the Development and Application of Integrated Pest Control in Agriculture have objectives that are closely related to those discussed at the present Expert Consultation. It was therefore recommended that as far as possible the Impact Monitoring Programme should be coordinated with these activities. The Consultation also noted that it had been called in pursuance of the following UNEP objectives and priorities:

> "Particular policy objectives: to anticipate and prevent threats to human health and well-being posed by contamination of food, air and water;
>
> Programme priorities: to support and encourage national and international efforts for assessing environmental effects of agricultural chemicals on man and ecological systems and for avoiding their undesirable effects."

At its first session, the Governing Council decided within the framework of "Earthwatch" programme that a "monitoring system should be developed first, for pollutants liable to affect weather and climate, and persistent and widely distributed substances liable to accumulate in living organisms and more through ecological systems, particularly along pathways leading to man...".

(Reference: Project Document. FAO/UNEP UN 32/6 No. 0102 - 74/005)

2. THE RESIDUE PROBLEM

2.1 History of the problem

During the past three decades, organic pesticides have become increasingly important in controlling pests of crops, animals and man. These chemicals have greatly increased agricultural yields and saved millions of lives. The amounts of these pesticides used have been increasing annually.

However, their rapidly increasing usage, often with insufficient technical advice or research, has brought in its wake many environmental problems. Pesticides have often been used as an insurance measure whether pests were present or not. They also have often been used with scant attention to their effects on beneficial organisms or to their transfer, by drift or other means, to non-target areas.

These factors, together with the poisonous and sometimes persistent nature of many of these chemicals, have created adverse effects such as (i) the emergence of new pests or of increased populations of pests of minor importance resulting from the elimination of parasites and predators; (ii) the development of resistance to pesticides in pests continuously exposed to pesticide residues; (iii) the killing of wildlife; (iv) the killing of food organisms such as fish and domestic animals; (v) harmful side-effects when pesticides are taken up into the tissues of organisms; (vi) death and illness of human beings due to contamination arising from careless storage and/or unsatisfactory transport arrangements; (vii) problems, largely of an economic character, arising from disquiet concerning residues in food, and involving the imposition of legal limits for residues.

Environmental hazards were appreciated and investigated quite early in the developed countries and diverse means of minimising them developed. By contrast, in the developing countries where the amounts used are expanding most rapidly, the extent of the problems has still not yet been fully assessed.

2.2 Amounts and types of pesticides currently used

Data on pesticide usage in developing countries were obtained from a questionnaire submitted to 99 governments by the FAO Plant Production and Protection Division in September 1974, as a result of an action proposal approved by the Sixty-Third Session of the FAO Council in July 1974. The questionnaire was designed to provide qualitative and quantitative information on pesticide consumption from 1971 - 73, together with estimated forecasts of usage from 1975 - 77, and is summarised in document AGP:Pest/PH/75/B44 of April 1974, which was presented as a Working Paper at this conference.

Total pesticide use in 1973 for 38 responding countries was 107.3 thousand metric tons of which 70% was insecticide, 20% fungicide and 10% herbicide. Fifty per cent of insecticides used in developing countries were organochlorines with approximately 30% organophosphates and 16% carbamates.

2.3 Regional usage of pesticides

Because several of the larger users of pesticides (e.g. Brazil and Pakistan) were unable to provide information on annual usage, it is difficult to formulate reliable generalisations on a regional basis but, clearly, certain countries are outstanding in their high level of consumption. In 1973, India, Mexico and Argentina accounted for 50% of the total pesticides used by the 38 countries submitting detailed figures on usage, with India alone consuming 25%; projected demands for these three countries accounted for considerably more than this.

Regional usage of pesticides is probably strongly influenced by availability at any time and from this aspect, facilities for manufacture and formulation are important. Such facilities exist and are becoming more significant in regions such as North and Central America and Asia where pesticide use is well-established, whilst in Africa pesticide use declined between 1971 and 1973, probably, at least partially, due to lack of foreign exchange and availability of chemicals rather than to demand. The highest regional levels of use occurred in North and Central America, where mean consumption for the countries responding to the questionnaire was about 11,000 tons for 1975. The comparable figure for Asia and Oceania (considerably inflated by the very large consumption for India) was about 5,000 tons and for Africa 1,000 tons.

It is important that figures for pesticide use should not be considered as the sole criteria for potential environmental problems. The environmental impact may depend much more on the kinds of application, including the application rates to particular crops, than on a country's total consumption.

2.4 Predictions of future usage of pesticides

The future estimated pesticide consumption for 1974 through 1977 in FAO paper AGP/PEST/PH/75/B44 indicates an overall rate of increase of 9% per annum. This is a considerably smaller increase than in the previous three years. However, it was estimated that consumption in 1975 will be double that in 1971. For the 38 countries surveyed, the projected consumption for 1975 was estimated to be 202,000 tons. The present Expert Consultation considered that these figures were very conservative estimates.

The comparatively rapid rate of increase in use of pesticides that has occurred, particularly in use of herbicides, is because these chemicals are relatively new agricultural tools for many developing countries as compared with countries with an advanced form of agriculture. It is obvious that the potential market for herbicides is likely to expand even more, as is evidenced by calculations that increases in consumption of herbicides for 1975-77 (25%) far exceeds the estimated growth in use of all pesticides (9%). It has been estimated that, in Africa, the herbicide consumption is expected to increase up to 70% annually for the immediate future.

The projected annual rate of increase in use of organochlorine insecticides from 1975-77 is 4% for South America and Africa, 7% for North and Central America and Asia 11%, with an average of 9%. The majority of these insecticides (65%) will be formulated in domestic factories.

The projected demand for organophosphorous insecticides exceeds that for any other class of insecticides. Annual rate of growth in South America is 11%, in Africa 22%, in North and Central America 14%, and in Asia 14%, with an average figure for overall consumption of 14%. The demand for organophosphorous compounds will account for approximately 30% of the total consumption of all insecticides during 1975-77. More than half of the increased demands have to be met by importation of the formulated products. Compared to the projected annual rate of growth of organochlorine insecticides (9%), that for organophosphate insecticides is estimated at 14%.

Currently, only 16% of the insecticides used are carbamates. It seems that the use of carbamates is mostly confined to certain regions such as Asia and North and Central America. Rates of projected annual increase for Asia and for North and Central America are estimated as 11%, for South America at 16%. India expects to be self-sufficient for carbamate pesticides in 1977.

2.5 Patterns of usage

Pesticides are applied in a great variety of ways, ranging from seed dressings, dips, localised applications, injections, broadcast treatments through foliar and aerial sprays. Each of these techniques is accompanied by different environmental hazards. For instance, at the extremes, seed dressings utilise extremely small quantities of chemical placed precisely where it is needed and such usage normally results in minimal residues in harvested crops. On the other hand, the seeds may be attractive to birds which may be killed from feeding on them. By contrast, aerial sprays sometimes apply large amounts of pesticides over large areas with considerable potential general environmental hazard.

The usage of pesticides is also closely correlated with the nature of the pests. In developing countries heavy usages of pesticides are for the control of (i) cotton pests; (ii) rice pests; (iii) vectors of arthropod-borne diseases in man and farm animals. As many as forty sprays have been used annually on cotton and this has comprised as much as 90% of the total pesticides used in some countries.

2.6 Economic aspects

At present, the manufacture of pesticides is concentrated mainly in developed countries. Only the final stages of manufacture, for instance, the formulation of the active ingredient into an applicable product, is increasingly being done in developing countries. Hence, pesticide usage depends markedly upon the economic position of the countries concerned relative to the developed countries in terms of whether they are able to afford those pesticides required for their particular pest problems. There is a tendency for cheaper, more persistent compounds to be used. Local production of pesticides as in India may solve the problem to some extent, but even in this situation the need to import raw materials, including oils and solvents may make this difficult. There are various other factors that should be considered in relation to the economics of pesticide usage. These include the capability to purchase or manufacture application equipment, the availability of water in arid areas for dilution of formulated chemicals, the facilities for training skilled technicians and extension workers, and the development of regulation and legislative systems, all of which can be expensive. It seems likely that the cost of pesticides will increase as the more expensive organophosphate and carbamate pesticides are substituted for the cheaper organochlorines.

2.7 Sources of residues

The amounts of pesticide residues present in a particular crop or a particular environmental area depend upon the types of chemical involved and various environmental conditions. In particular, certain organochlorine insecticides are structurally stable and may persist in the environment for many years, whereas most organophosphorous insecticides are rather unstable and ordinarily decompose in a very short time. The amount of residues present at any time depends not only upon the inherent stability of the pesticides they come from, but also on the amounts used and the frequency of application and also on climatic factors. Residues occur not only in treated areas, but they also reach untreated areas due to spray drift, to movement of migration of contaminated animals, and other causes.

3. ENVIRONMENTAL PROBLEMS

3.1 Pest problems

3.1.1 Development of new pests

Pesticides may destroy not only the target pest organisms but also beneficial species including parasites and predators of harmful pests. In recent years, there have been instances of excessive build-up of certain pests that are virtually new or of only minor importance until recently. For instance, there has been an increase of green leafhoppers on rice in areas of intensive use of BHC and of white flies on cotton after the introduction of DDT in the Sudan Gezira. Such pesticide-induced disturbances may be more severe in tropical developing countries where ecological conditions tend to favour control by natural enemies.

3.1.2 Development of resistance to pesticides

It is now well-established that the development of resistance following the continuous use of pesticides is extremely common. Presently, over 250 species of insects have shown resistance to one or more insecticides. The development of cross-resistance to other pesticides of similar or different chemical structure makes the problem more acute (see Brown, A.W.A. "Development of Resistance to Insecticides." Proc. FAO Conference on Ecology in Relation to Plant Pest Control. F.A.O., AGP: 1973/M/14 p. 73-81).

The continuous use of broad-spectrum persistent insecticides is bound to intensify the resistance phenomenon. For example, in several Central American countries, it is no longer feasible to grow cotton on a commercial basis because of the large number of applications of pesticides necessary to control resistant pests, especially when cotton prices are low.

We know very little about resistance in organisms other than in insects. There are indications of the development of resistance in certain fish species, in field mice, in micro-organisms, and possibly in some birds. No resistance has yet been reported in aquatic non-target organisms which form vital links in the food chain or in those at higher trophic levels. However, there is reason to expect that manifestations of resistance could appear in non-target organisms after repeated and prolonged exposure to toxicants. It is to be noted that, so far, no resistance has been found in tse-tse flies. But this may well be due to the fact that it has not been subjected to contact with insecticides to an extent comparable with many other pest species.

3.2 Hazards to the biota

3.2.1 Terrestrial ecosystems

Movement patterns and degradation. Within terrestrial ecosystems pesticides have complex patterns of movement and degradation depending upon method of application, chemical and physical structure, ambient temperature, and precipitation. Much more data exist on the dynamics of pesticides in temperate ecosystems than in tropical ones. There is some evidence that pesticides may degrade much faster in warm, humid climates than in dry, temperate ones, but much more information is needed. The rates and pathways of degradation can be influenced by chemical interactions and physical and biological conditions.

Effects on non-target organisms. From past experience, it has become obvious that the use of pesticides in agriculture can directly or indirectly affect non-target species in terrestrial ecosystems. There may be serious effects on non-target species in the target areas, such as effects on soil micro-arthropods, earthworms, pollinating insects, birds and mammals. Certain types of pesticides, in particular those which are relatively persistent, may have an effect on non-target species living outside the perimeter of the target areas if the compound is transported from the target areas by drift or by biological carriers. The likelihood of a species being affected depends on many variables including its intrinsic sensitivity to the compound, its trophic position in the system, the stage of its life-cycle during the period the pesticide is present in the environment and the horizontal distribution pattern of both the species and the compound.

Persistence is of special concern because not only is chronic exposure more likely to occur if the compound is persistent, but there is also a greater chance that secondary poisoning or some delayed effect may be induced through continued exposure. In this connection, it is relevant to recall that relatively non-persistent compounds can also be present for considerable periods if they are applied repeatedly. Past experience has demonstrated that certain types of applications may have specific associated hazards, e.g. seed dressings to certain seed-eating birds.

3.2.2 Aquatic ecosystems

Pathways of movements. Contamination of aquatic ecosystems by pesticides does not necessarily result from deliberate treatments of water systems. A variety of possible pathways from the surroundings exist, e.g., transport in drainage water, surface runoff, blowing of contaminated dust onto the water and volatilisation from soil with subsequent fallout in precipitation onto water. Contamination also sometimes arises from leakage from spray tanks and/or unsatisfactory practices in their cleaning after use.

Transfer of pesticides within the aquatic system. Depending on the properties of the pesticides, some degree of uptake by aquatic organisms is likely to follow from the entry of any pesticide into an aquatic system. Due to their persistence and higher lipoid but lower water-solubility, the more persistent organochlorine pesticides such as DDT have been found to be transferred and accumulated in some animals belonging to higher trophic levels. Organophosphorous pesticides persist much less than organochlorines in water and there is little indication of residue build-up. Many persistent pesticides, including persistent organochlorine and organometallic compounds such as mercurials, are eventually deposited in the bottom sediments, but a re-cycling within the system by turbulence as well as a transport from water to the atmosphere via the surface film must be recognized.

Effects on non-target organisms. In aquatic systems, most attention, not unnaturally, has been paid to the direct toxicity of pesticides to fish. However, observations of sub-lethal effects on fish are accumulating and there are indications that indirect effects on the ecosystem such as the disturbance of population dynamics, changed food requirements, reproduction, behaviour and photosynthesis, may be important.

3.2.3 Misuse of pesticides

It should be recognized that there are cases where pesticides are deliberately used for purposes other than those for which they were designed. This is particularly true in parts of the developing world where, for example, they are used to poison water in order to obtain fish or salt licks to kill game animals, for human consumption. Any examination of the pesticide impact should not lose sight of such potentially dangerous practices.

3.3 Relevance to man

The introduction of pesticides and their residues or breakdown products into ecosystems may have a threefold impact on man, by reducing the productive capacity of his environment or by contamination of either his food sources or of his work environment.

Dramatic short-term increases in crop yields could possibly mask long-term deteriorations in soil fertility due to disturbance of nutrient cycling through the effects of pesticides on the soil biota. Pesticide contamination of aquatic systems could also reduce the potential of such systems for fish production which may be an important protein source in many countries.

More directly, residues or their breakdown products could have a more obvious direct effect on man's health. Thus, the work exposure of the agricultural laborer particularly the dermal exposure to foliar pesticide residues has resulted in many poisoning cases. In the rice crop dermal exposure through standing in water may also be important. Furthermore, the known occurrence of appreciable amounts of certain pesticide residues in adipose and blood tissues of the general population in many countries gives some reason for concern.

In another situation, the resurgence of malaria in Central America and the Sudan due to vector resistance which has followed the use of pesticides in agriculture has very real significance to man's survival in these rural ecosystems.

3.4 Global transport

Pesticides may be transported in the environment in various ways. However, very few actual measurements are available to indicate the quantities involved in global transport. Only a few observations are available concerning their transport to the upper atmosphere and their subsequent precipitations onto land or sea. Volatilization, a process that occurs more readily in tropical areas, is one means of transport from one place to another. Under flooded conditions, such as in paddy fields, substantial volatilization (e.g. of BHC) may occur even more readily.

The migration of fish containing residues and the consumption of pesticides in food by migratory birds also contribute to the global transport of pesticides. However, in the absence of relevant data on the amounts of pesticides involved in global transport, it is not possible to indicate any trends or changes.

4. MONITORING AND MINIMIZING RESIDUES

4.1 Impact monitoring

In an impact monitoring programme, both biological and chemical monitoring may be essential in the early stages. For chemical residue monitoring, the timing, kind, location and number of samples must be related to the usage of the pesticides and anticipated environmental problems. In the same way, the pattern of biological monitoring must be related to expected hazards.

4.1.1 Aquatic monitoring

The impact of a pesticide upon an aquatic system is not usually confined to immediate areas treated or contaminated with the pesticide. Monitoring should therefore be designed in the first instance to reveal the degree of movement or immobilization of pesticides in such systems.

Chemical monitoring of aquatic systems. There are three main components of aquatic systems, water, bottom sediment and the biota. Usually, all three should be sampled for residues initially, but subsequently, depending upon the chemical and physical characteristics of the pesticide, it may be adequate to sample only water, mud or key indicator species of organisms that readily take up residues from the particular pesticides.

Biological monitoring of aquatic systems. The effects of the residues can be assessed by monitoring changes in populations of either the same key indicator species that were selected for chemical monitoring or choosing other species, either because of their known sensitivity to pesticides, or because they are particularly vulnerable due to their position in the particular ecosystem. Biological monitoring can also be done by assessing changes in species diversity in the ecosystem or by studying physiological and behavioural parameters (cholinesterase inhibition, activity of liver enzymes, body weight, reproductive ability, sense of balance, etc.).

4.1.2 Terrestrial monitoring

Terrestrial ecosystems include not only soil and its biota but also plants and animals that live above ground. According to the method of application of pesticide and the particular aspect being investigated one or both of these systems should be studied.

Because a large proportion of the pesticide eventually reaches the soil and becomes bound on to various soil fractions, its impact is much more localized in terrestrial ecosystems than in aquatic ones. With the exception of movement in run-off water and volatilization, residues often do not leave the system and their impact is much easier to assess.

Chemical monitoring in terrestrial systems. The main components of terrestrial ecosystems are soil, plants and animals, and in any general studies residues in all three of these components should be monitored. Soil residues are aggregated in all three dimensions so both the horizontal and vertical distribution should be monitored over an area that depends upon the method of application of the pesticide. Not only the crop, but also those elements of the macroflora and macrofauna that are considered to be at hazard should be monitored for residues. The criteria for deciding which organisms should be selected depend upon available information as to their tendency to accumulate residues as well as upon the particular problem.

Biological monitoring of terrestrial ecosystems. Two main kinds of population assessment and change are necessary. These are firstly, enumeration of those species of animals that are confined to the treated area and secondly, those animals that spend only part of their time in the treated area exposed to pesticide residues. Where possible, key indicator species should be selected and used, following criteria similar to those used for aquatic ecosystems.

4.1.3 Air monitoring

It may be necessary to monitor air, to obtain information concerning the distribution of pesticides by drift beyond the site of application. Such measurements may also be necessary in assessing the risk to agricultural workers, particularly when volatilization of the pesticide may be occurring.

4.1.4 Interpretation of chemical and biological monitoring data

In many instances, the provision of chemical data alone is sufficient to reveal sources of release of a pesticide into the environment that were unsuspected, or due to pesticide use that was excessive or not necessary for achieving the particular agricultural objective. Examples are residue measurements that reveal continued run-off of liquid from cattle dip baths or from spraying machinery. Chemical measurements are also necessary to provide information on which to select methods of application that leave minimum residues on foods, or that result in a maximum application of the dose to the target with a minimum transfer by drift or similar mechanism to surrounding areas. The use of such chemical data is often sufficient to avoid contamination or to enable remedial action to be taken to deal with existing problem situations.

In some situations, although either chemical or biological monitoring results may provide indications of environmental impacts, correlation between the two types of data is essential in establishing cause and effect relationships, particularly in the absence of control situations. The effect of the residue may be direct; or it may be indirect due to influence on food sources or predators.

4.2 Avoidance of residue problems

Residues, and hence environmental hazards can be minimized by well-established procedures of legislation, education, improved use of pesticides and by integrated and non-pesticidal methods of control.

4.2.1 Legislation

Experience in many developing countries has shown that the introduction of legislation to require that adequate labelling and other steps are taken in pesticide distribution, sale and use provides a means of ensuring against major undesirable practices. To be effective, such legislation must be backed up with a central technical organisation and with laboratory facilities for the examination of pesticides and for analysis for pesticide residues. FAO and WHO have issued advisory literature and have assisted in national developments of these objectives. This assistance in various cases has included support for laboratory activities with funds provided by the United Nations Development Programme and/or other sources.

4.2.2 Education

Many of the environmental hazards associated with pesticides arise from misuse. In some instances, chemicals are applied at excessive rates, or for insurance purposes, when no real need has arisen. The method of application employed also influences the amounts released into the environment. Education of the applicators can obviate many such misuses. Such education can be provided by improvements in extension services, by provision of literature, by radio, by local lectures and by similar means.

4.2.3 Improved methods of application of pesticides

Some environmental problems have been due to the use of broadcast treatments. With the development of improved application equipment it has been possible to use much smaller doses, applied in narrow bands or spot treatments or in granules or microcapsules that only release the pesticide gradually. All these techniques serve to decrease the residues.

4.2.4 Other methods of pest control

In addition to the many traditional procedures of cultural methods to avoid pest problems, much attention is now being paid to the development of methods of controlling pests by management practices and by the scientific integration of chemical with biological and other methods of pest control which minimise reliance on chemical pesticides. These activities are being actively pursued by a global FAO/UNEP project which receives scientific and technical support from the FAO Panel on Integrated Pest Control.

5. KINDS OF ACTIVITY IN IMPACT MONITORING

5.1 Phases in an impact monitoring scheme

Stages in the development of an impact monitoring programme have been represented in the form of a flow chart (see Appendix I). The stages involved may be defined as follows:

5.1.1 Phase 1 - Problem definition and evaluation

Potential environmental problems can be identified and the requirements for their solution can be clarified. The following criteria can be used in establishing priority areas:

(i) Suspected or actual occurrence of undesirable side effects associated with pesticide use, e.g., fish mortality in flooded rice ecosystems, the finding of excessive residues in marketed produce following pesticidal treatments.

(ii) Actual and potential situations of intensive pesticide use, particularly where compounds of high toxicity and/or persistence are involved.

(iii) Situations of known or potential ecological vulnerability, e.g., fish spawning grounds or bird breeding areas.

(iv) Situations where new uses of pesticides are planned in association with changing cultural practices.

Assessment by consultants. The nature and implications of the problem should be assessed by consultants, usually on the basis of visits to the area. They should also recommend possible courses of action, which could include short-term studies or full proposals for project activities requiring support from UN or other agencies.

5.1.2 Phase 2 - Preliminary project activities

Accumulation of relevant information. This should be an early stage in all programmes and should include the collection of all available data on pesticide usage associated with the area, or problem under study, together with published information on its behaviour and toxicology. Relevant ecological data which may indicate potential organisms or biological processes at risk should also be reviewed.

Establishment of suitable residue and biological assessment capacity. Appropriate assay methods, both chemical and biological, should be chosen and facilities and personnel established for their implementation, preferably in existing laboratories.

5.1.3 Phase 3 - Technical components of programme

A wide range of kinds of activities, at one extreme encompassing the provision of advice on specific issues of local importance and at the other encompassing full-scale investigations of issues of broad significance or the provision of extra support for a range of training or extension activities are envisaged as possible components of an impact monitoring programme. These component needs will be influenced by the circumstances of each case, including the location, the crop, the climate, the properties and the extent of use of the pesticide and the method employed in its application. Although the detail and the depth to which studies can be undertaken in a given location at any time may have to be determined by the available technical staff and laboratory facilities, it must be remembered that impact monitoring of some kind is desirable and almost invariably possible in any circumstance where agricultural pesticides are being used on a substantial scale.

The following list of activities, that is neither exhaustive nor exclusive, indicates types of work that may be involved. (Also see 5.2 and 5.3).

Pesticide studies. The fate and distribution of pesticides from relevant uses under field conditions should be studied. In this area, priority would be given to investigations likely to provide data of general applicability rather than to a limited range of situations. Such studies should be correlated with application techniques and prevailing climatic conditions. It is conceivable that sufficient information may be acquired from such investigations to answer the problem, e.g., the source of a known occurrence of environmental contamination might be identified.

Pilot studies. In some situations, a pilot study may be required to assess the nature and depth of the problem. Such a study could involve the application of a selected pesticide(s) to restricted areas, e.g. experimental plots, and following its distribution, behaviour and effects upon the biota.

Detailed studies. In more detailed studies both direct and indirect effects of the pesticide upon the species diversity of the area and upon the size and structure of populations of key organisms would be followed in association with measurements of the residues in different locations. Such investigations could include: (i) toxicological studies, e.g. establishment of median lethal dose levels; (ii) detailed biological investigations into reproductive capacity and behaviour; (iii) studies into effects on primary production as yield in crop systems or secondary production as animal protein in grassland or aquatic systems.

5.1.4 Phase 4 - Problem solving

Studies such as those outlined under 5.1.3 may be applied to the assessment and evaluation of existing problem situations so that appropriate modifications can be made in pest control procedures to minimise environmental impacts. They may also be incorporated into programmes designed to provide information on the potential impact of future pesticide use. The problem of misuse can best be solved by education.

5.2 Some relevant ongoing projects

A number of ongoing projects relevant to the Impact Monitoring Programme were identified. This list is not a comprehensive one and was made up from items of work referred to in the background papers submitted to the meeting.

5.2.1 Ecological impact of DDT upon an agricultural ecosystem in Nigeria

This is a co-operative venture between the International Institute for Tropical Agriculture (IITA) and the centre for Overseas Pest Research (COPR) of U.K., concerning the behaviour and biological effects of DDT when used to control pests in cowpeas. Work began in 1973 and the aim of the programme is to establish whether DDT influences the productive capacity of soil by interfering with soil processes in such a way that nutrient cycling is disrupted. In addition to the measurement of residues, a wide range of biological responses is being monitored in an attempt to develop suitable methodologies for future studies in different agricultural situations.

5.2.2 Effects of endosulfan on freshwater organisms in Botswana

In Botswana as part of a tsetse fly control trial, a joint COPR/Tropical Products Institute project has been mounted to investigate the effects of endosulfan on freshwater organisms in the Okavango Delta. Since this chemical is known to be very toxic to freshwater organisms there is concern over the effects on the potential of the area as a fisheries resource, in addition to more general environmental considerations. Particular attention is being given to fish and aquatic invertebrates which serve as food organisms. The Tropical Products Institute is analysing residues of biological materials and advising on other aspects of the residue programme. The project began in 1975, and is expected to continue for two years with a possible major expansion, should a large-scale eradication programme be undertaken.

5.2.3 Monitoring residues in various tropical countries

Research activities in the field of pesticide ecology and in monitoring of residues associated with both crop protection and vector control are being carried out under the auspices of the Overseas Development Ministry of the U.K. in Nigeria, Botswana, Malawi, Kenya and the Caribbean. A study of the concentration and distribution of DDT following cotton spraying in Southern Malawi is being conducted by the Tropical Products Institute with special reference to the contamination of fish populations in the Shire River.

5.2.4 Environmental hazards associated with the use of pesticides in Egypt

A preliminary study into pesticide usage and into the possible environmental risks was undertaken in Egypt for FAO as part of a UNDP funded project. Recommendations were made concerning the study and avoidance of these risks. These included recommendations for measuring residues in foods, soil and water and for controlling uses in field sites with a view to minimising any hazards that exist.

5.2.5 A systems management programme to reduce the environmental effects of pesticide use in Central American cotton production (UNEP Project No. 0205-73-002)

Information is being collected on the environmental effects of pesticides used on cotton and also on human health. The aim is to substitute alternative control measures for those causing undesirable environmental effects.

5.2.6 Monitoring of pesticide residues in areas sprayed for the control of the desert locust (FAO/DANIDA project - TF INT/100 (DEN))

This project was formulated in 1973 with the aims of determining the effects on wildlife of persistent pesticides used to control the desert locust. The project, centered on a specially equipped laboratory in Teheran, covers three years from October 1974 and is concerned with Afghanistan, India, Iran and Pakistan.

5.2.7 Environmental effects of tsetse control

In Nigeria the possible environmental impact of pesticides used in tsetse control is studied by the Tsetse and Trypanosomiasis Division in Kaduna in collaboration with the Department of Toxicology of the Agricultural University in Wageningen, The Netherlands. They have observed and assessed certain undesirable effects, particularly on insectivorous birds and non-target insects. This work is continuing.

5.2.8 Persistence of pesticides in soils from uses on rice

Studies on the behaviour and persistence of commonly-used pesticides in rice soils under flooded conditions have been made at the Central Rice Research Institute, India, for several years.

5.2.9 Development of competence and of laboratory facilities in the determination of residues of pesticides in various countries

Laboratories for measuring residues of pesticides following known user practices are being initiated or extended, with assistance from FAO/UNDP and bilateral agencies including those of the German Federal Republic, the Netherlands, the U.K. and the U.S.A. The countries involved include Brazil, Egypt, Iran, S. Korea, Morocco, Poland, Sudan, Sri Lanka, the Philippines, Indonesia and San Salvador.

These activities hitherto have been largely stimulated by the need for these countries to obtain information at the point of production, concerning residues in foods for export or home consumption. With exported foods, it is often necessary to ensure that residues are within limits set by the importers, and by associating residues measurements with known pest control practices, it is often possible to modify these practices to meet with importers' requirements. Where such modifications are not possible, residue data are required to demonstrate that particular residue levels are to be expected following good agricultural practice and may be acceptable as legal limits at any particular time. Such activities need to be extended if developing and producing countries are not to be at a disadvantage in international discussions (e.g., under the Codex Alimentarius Commission) concerning acceptable limits for residues in foods in international commerce.

Such activities also need to be extended to the measurement of residues in materials other than food if the authorities in these countries are to obtain information necessary for controlling other impacts on the environment.

5.3 Examples of potential projects

The meeting discussed the possibilities of identifying problems that required urgent attention. Several usages of pesticides were suggested as causing actual or potential problems. These are:

5.3.1 Cotton

The crop on which the largest amounts and range of pesticides are used is cotton. It would be of value to initiate more extensive investigations into the occurrence of residues following the use of various pesticides for this purpose and into their environmental impact on terrestrial organisms. This activity would be in accordance with the recommendations of the FAO Panel of Experts on Integrated Pest Control (see p. 11 to 15 of "The Development and Application of Integrated Pest Control in Agriculture" Report of *ad hoc* session of FAO Panel of Experts. FAO Rome. AGP:1974/M/8) and the data would supplement the work of that Panel on this subject. Laboratory facilities will be needed in relevant countries to undertake this work.

5.3.2 Rice

Large amounts of pesticides are used on rice and there have been numerous reports of these chemicals killing fish, particularly where fish culture is associated with rice-growing. The most widely used insecticides on rice are probably BHC, carbofuran and endosulfan. There is an urgent need for investigations into the scale of fish kills and of other ecological side effects from these usages of pesticides. There also are other hazards associated with the use of pesticides on rice that need investigation, such as the effects on workers of standing in contaminated water for extended periods.

5.3.3 Control of tsetse

Considerable amounts of pesticides are used in preventing attack of tsetse fly on domestic animals, and the pesticides used often are persistent compounds which are sometimes applied from the air. These chemicals represent a potential hazard to wildlife and already there have been investigations into these problems. The meeting recommended that impact monitoring of areas where pesticides are used for tsetse control should be considerably extended.

5.3.4 Control of locusts

Persistent pesticides, particularly dieldrin, have been found to be the most efficient compounds for the control of locusts. As this use has raised questions concerning possible hazards to wildlife in the treated areas, the meeting considered that there was a good case for continuing and extending the studies being undertaken on this problem and about which a preliminary report was made available to the meeting.

5.3.5 Preliminary project suggestions

Specific suggestions for project activities discussed in a preliminary way at the consultation, included a proposal for studying the distribution and effects of pesticides used on rice in Malaysia, where it has been suggested that populations of fish, used as food, are declining from this cause. A similar study was proposed in the Philippines, where fish kills have been observed on freshwater lakes partly fed from water from paddy rice cultivation; also a more intensive study in India into the behaviour and persistence in rice soils, of the various pesticides commonly used in rice production. Each of these would be associated with existing laboratory facilities. Suggestions were also made for further work on the distribution of pesticide residues amongst wildlife in Thailand and for obtaining more information concerning the fate of the considerable quantities of pesticides applied annually to cotton in the Sudan.

These were preliminary ideas put forward by those attending the consultation, and they call for further examination and consideration as part of the future development of the proposed programme. (See Section 8).

6. TECHNICAL, SCIENTIFIC AND MATERIAL INPUT

6.1 Field techniques

Valuable indications of environmental problems due to pesticides sometimes can be obtained from simple observations by field naturalists. Examples are observations of the occurrence of bird or fish casualties directly associated with the application of a pesticide. In many situations however, close correlation of biological with chemical observations is necessary to assess whether changes in biological parameters are causally related to the presence of the chemical.

The biological observations may relate to the status and changes at the population or ecosystem level by appropriate census techniques, or at the physiological or behavioural level through measurements and observations on individual organisms. The nature and number of such observations, as well as the nature and choice of related samples to be examined chemically must depend on the problem under investigation. Statistical advice is desirable when planning such investigations.

6.2 Laboratory facilities and techniques

One or more local laboratories should be available or set up to make the necessary measurements. Where possible, existing facilities, equipment, and supplies should be utilized and supplemented. The long-term objective should be to make laboratories in the developing countries capable of undertaking measurements, including measurements of residues in food, as the need arises from changing practices in the use of pesticides.

To execute suitable measurements as part of a monitoring programme in a region, close collaboration between national laboratories in the region and a central coordinating institute of generally accepted competence in the subject should be established. The coordinating institute, together with possible existing laboratories in the area, will provide expert advice on analytical and biological techniques, arrange for training of regional scientists and laboratory technicians, provide standards, and information on subjects of interest, and assist in interpreting the accumulated data.

The routine monitoring, i.e. sampling and analysis, should be done by the national institute or by a special regional laboratory in the area under investigation. In order to enable these laboratories to undertake this task, their capabilities should be strengthened as regards manpower, equipment and library facilities. This would include organization of fellowships for in-service training of scientists, purchase of necessary equipment and assistance by experts for installation of instruments.

6.3 Personnel

Wherever possible, even the minimum personnel should possess competence in biology, toxicology and chemistry. In countries where large programmes will be established, additional biologists and chemists with expertise in many sub-areas will be required and full-time plant protection experts, epidemiologists, climatologists and data processing experts and systems analysts may need to be added to the programme.

Where possible, advantage should be taken of the experience and training of local candidates for staffing the laboratories. These individuals may require some specialized additional training. In the long-term, it may be desirable and worthwhile to train individuals at the Masters and/or Doctorate levels for expanding the laboratories' capabilities and for more detailed monitoring programmes, but this should not be done if it delays starting the programme.

Since most of the laboratory analyses will be done by semi-technical individuals, short-term training in specific areas of chemistry or biology should be implemented. This may be accomplished in the developing countries by local talent and/or by experts from developed countries. If at all possible, this training programme should be conducted in the laboratories of the developing countries.

6.4 Flow of information

Information collected by the monitoring programmes should be made available to as many developed and developing countries as possible. This may be accomplished on a regular basis through the distribution of a newsletter containing summaries of data. On each project, a flow of information between national and international agencies would be most desirable.

6.5 Budgeting

The cost of various projects may differ greatly according to their complexity; it can range from only the cost of sending a consultant to a country to review a problem, to the setting up of a well-equipped residue laboratory with ancillary facilities and field staff. An attempt has been made (see Appendix IV) to provide some guidance on the requirements for setting up residue laboratories including the costs at different levels. It is strongly recommended that the facilities should be provided in stages and in no instance should the laboratory be more complex than is required in the particular situation.

An FAO/UNEP Secretariat will have to be established in order to develop the project document. On the basis of this document, the several sub-programmes will be sectorized according to the component activities within the project. Multinational and donor agencies will be approached in order to finance such a programme. Each donor might be prepared to assume financial responsibility for one facet of the programme and one type of activity (e.g. training, monitoring, etc.) or a single grant could support the whole programme.

7. ACTIVITIES AND INTERESTS OF AGENCIES

7.1 From their contributions to the consultation, it was noted that IAEA, WHO and UNESCO were each pursuing activities and had interests related to the proposed impact monitoring programme in developing countries.

7.2 So far as IAEA is concerned, the common interest is centered on the Joint FAO/IAEA Division, located in Vienna. This Division is instrumental in supporting an international programme of isotopic-tracer aided studies on the distribution and fate of pesticides and other chemicals in the environment. Certain of the items of research included in this programme would contribute directly to the proposed impact monitoring programme.

7.3 For many years WHO has been concerned and has studied the implications on man of pesticides, whether used in public health or for agricultural purposes. These interests have particularly involved public health implications derived from the exposure to pesticides from occupational or environmental sources, vector-borne diseases and vector resistance induced by some agricultural pesticide uses, as well as pesticide use for vector control, which in some instances may have a direct input for the proposed monitoring programme. It was also noted that through the annual joint FAO/WHO Meetings on Pesticide Residues, which are concerned with the evaluation of the risks to man from residues of agricultural pesticides in foods, and through the FAO/WHO/UNEP Food Monitoring Programme, which is responsible for assembling information on the occurrence of contaminants of food, WHO is directly interested in the development of the proposed programme.

7.4 So far as UNESCO is concerned, the main point of contact lies in the Man and the Biosphere Programme (MAB), in which Project 9 is on the "Ecological Assessment of Pest Management and Fertilizer Use on Terrestrial and Aquatic Ecosystems". The MAB Programme is an intergovernmental and interdisciplinary programme of research which emphasises an ecological approach to the studies of the inter-relationships between man and the environment, placing special emphasis on research and on the broad ecological effects of man's manipulation of ecosystems and on the repercussions of the environmental changes on man, considered as a biological, sociological and economic entity. Along these lines, the pesticide part of MAB Project 9 expresses particular concern for broad environmental consequences of widespread use of chemical pesticides. Since pesticide use is primarily associated with the need to provide food for an ever-expanding human population and the maintenance of health by suppressing vectors of serious disease, the development of MAB Project 9 has been envisaged since its beginnings as being undertaken in close cooperation with the competent international agencies, and particularly with FAO and WHO, taking advantage of their existing mechanisms: indeed, there has been very close cooperation with FAO in drafting the outline scientific context of the Project, which lays emphasis on broadly ecologically-oriented research, including research on biological productivity and effects on non-target organisms.

7.5 The meeting noted that by comparison with the MAB Programme, which covered a broad ecological approach, the impact monitoring programme proposed would be strictly problem-oriented: thus it would lay emphasis on items of work aimed at improving the level of information on which authorities in different places take decisions regarding current and immediately projected usages and problems.

7.6 After noting that close relationships already existed between those responsible for the above-mentioned programmes in the respective agencies, the meeting recommended that they should all be invited to participate in the activities of the proposed FAO Panel of Experts on Pesticides and the Environment, which would be intimately concerned in the development of the impact monitoring programme.

8. RECOMMENDATIONS OF THE MEETING FOR AN IMPACT MONITORING PROGRAMME FOR AGRICULTURAL PESTICIDES IN DEVELOPING COUNTRIES

8.1 Requirements and priorities

8.1.1 Urgent measures should be taken to initiate missions to analyse and identify the components of specific environmental problems. The priorities should be guided by the following criteria:

(i) Suspected occurrence of undesirable side-effects arising from the residues associated with particular uses of pesticides in agriculture.

(ii) Actual and potential situations of intensive pesticide use, particularly where compounds of high toxicity and/or persistence or situations of known ecological vulnerability are involved.

(iii) Situations where new and possibly potentially hazardous uses of pesticides are planned.

8.1.2 The meeting concluded that major areas for concern were the heavy use of pesticides on cotton and rice, in locust control and in the protection of livestock from pests such as tsetse and that action is especially needed in these areas as soon as possible.

8.2 Organisation of the programme

8.2.1 FAO should, as a matter of urgency, in cooperation with WHO, UNESCO, IAEA and other appropriate agencies coordinate, promote and seek funding for an international cooperative programme for monitoring the environmental impact of agricultural pesticides.

8.2.2 The proposed FAO Panel of Experts on Pesticides and the Environment should be convened and should serve as a formal advisory body to the programme.

For efficient implementation of the Programme a full-time professional officer at FAO headquarters should be responsible for running the secretariat of the Panel and the liaison between the component projects of the programme and the cooperating organisations.

8.2.3 Copies of the report on this Expert Consultation should be distributed widely to developing countries with an accompanying invitation to recipients to draw the attention of the Secretariat in FAO to specific problems of impact monitoring that warrant support within the programme. To facilitate this distribution of information, the main papers contributed to the meeting should also be published.

8.3 Development of the programme

The meeting also recommended that the following specific activities should be pursued as part of the monitoring programme:

(i) Short term visits to developing countries by chosen experts in a consultancy capacity, to advise on existing or potential environmental problems arising from new or existing practices in the use of pesticides in agriculture. This should include preliminary sampling surveys; the provision of advice on the kinds of study needed to investigate possible problems from such uses and the drafting of project proposals for their implementation.

(ii) Individual projects in the programme should be funded and managed by national, bilateral or international organisations as appropriate, and should be provided with technical advice and assistance via the Panel on Pesticides in the Environment to be set up by FAO in association with UNEP for the purpose.

(iii) Once specific projects are identified, support for existing laboratories in plant protection institutes and similar institutions should be given, to raise their competence in monitoring the distribution and impacts of pesticides used in their localities. This may be by the provision of experts on a medium term basis, by training of appropriate qualified staff, with equipment, or in other ways.

(iv) Support for fellowship training of graduate staff, on an intensive basis, in methods of determination of residues, for periods of six months or more, also for selected staff from developing countries to attend seminars and specialised meetings concerned with the monitoring of residues of pesticides in the environment.

(v) Information on the usage of pesticides in developing countries is needed and should be obtained prior to establishing a project in a particular country.

(vi) Efforts should be made to overcome the lack of availability of information and literature relevant to recommended projects.

(vii) Information be made available on research and training programmes organised and supported by member countries which are relevant to the problem of impact monitoring of pesticides.

(viii) Both laboratory and field methods for the detection and measurement of changes in the susceptibility of relevant non-target organisms should be established and, where possible, appropriate organisms identified as indicators of pesticide contamination and monitored.

(ix) To ensure the comparability of results, methods should be standardized and if possible a regular check sample programme be organized.

(x) To permit the maximum degree of participation by all countries, the monitoring techniques adopted should be of a degree of complexity appropriate to the problem.

8.4 Related activities and background studies

8.4.1 The meeting further recommended that, as an essential complement to the monitoring programme, the following supporting activities should be initiated and their progress kept under review by the FAO Panel of Experts.

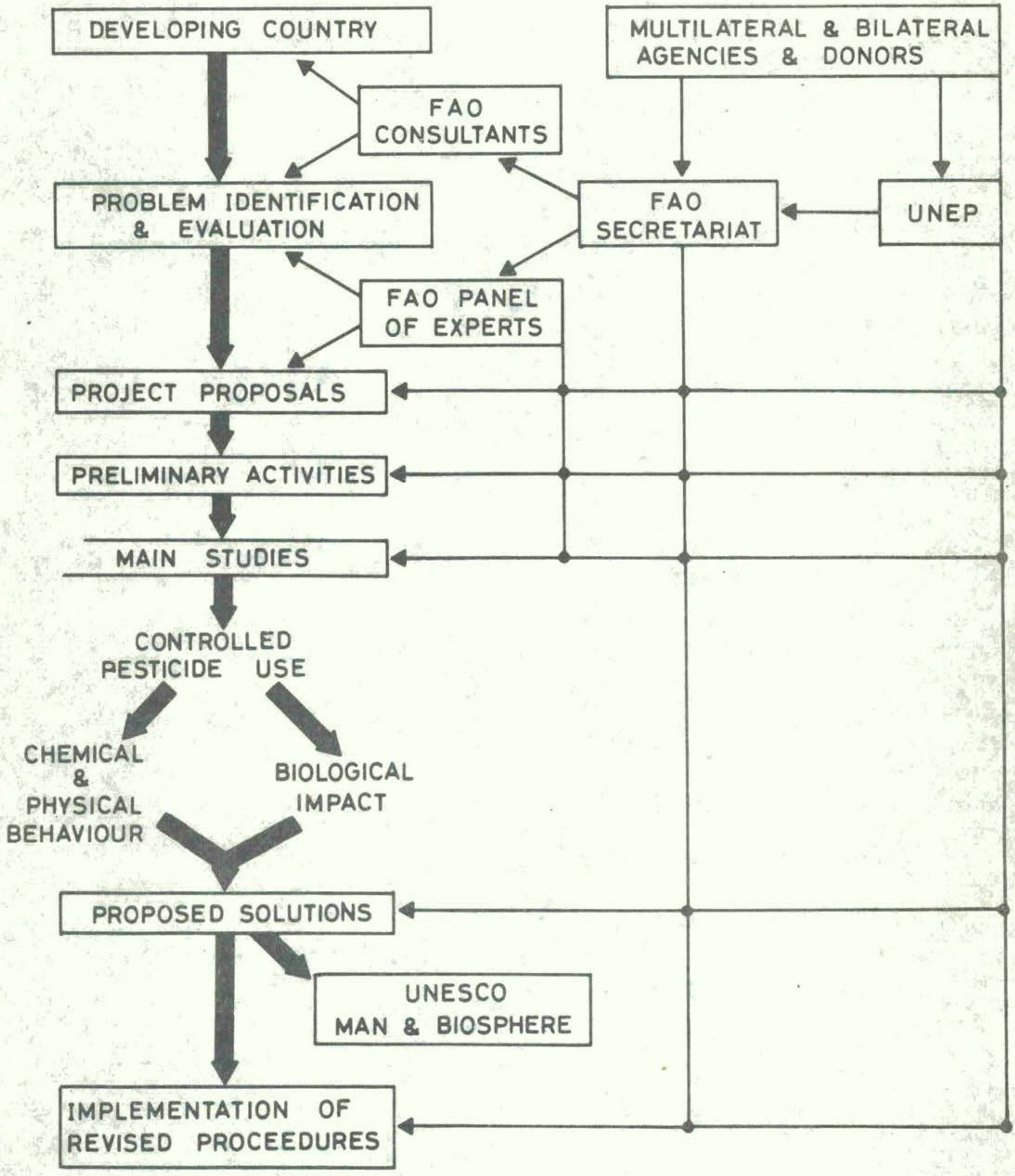
(i) Support should be given to research into the behaviour and persistence of pesticides in tropical ecosystems.

(ii) Studies should be made of the relationship between long-term soil contamination by pesticides, and plant productivity as measured by crop yield and quality.

(iii) Whenever appropriate the above activities should be coordinated with the "Man and the Biosphere Programme" of UNESCO, with the FAO/UNEP "Cooperative Global Programme for Integrated Pest Control in Agriculture", with the FAO/WHO/UNEP "Food Contamination Monitoring Programme" and with other international monitoring programmes concerned with pesticides.

(iv) In assessing and evaluating the effects of pesticides, the nature of their interaction with the major elements of the environment, in particular, soils, water, plants, animals, man and climate should be characterized.

PROPOSED STRUCTURE OF AN IMPACT MONITORING PROGRAMME



APPENDIX II

ESSENTIAL AND MINIMUM REQUIREMENTS FOR THE ESTABLISHMENT OF A PESTICIDE RESIDUE LABORATORY

INTRODUCTION

Facilities for the determination of the occurrence of residues are necessary requirements in any kind of programme of impact monitoring of residues of pesticides. In a developing country, a new laboratory may have to be established or an existing one supplied with additional equipment.

It is convenient to consider laboratory requirements in three stages. The first stage is envisaged as enabling simple measurements to be made in a semi-quantitative manner to obtain general information on the fate of residues of specific pesticides known to have been released into the environment. But this stage would not generally be suitable for monitoring of residues in foods to meet legal residue limits. The second and third stages would enable residues of a wider range of pesticides and of substrates to be covered. They would involve the use of more complex procedures and require staff with broader training and experience than in Stage 1.

It cannot be over-emphasized that these notes are only intended to provide broad general information. The requirements of particular situations will vary widely according to problems being studied and with the basic facilities (accommodation, water and electricity supplies etc.) that can be obtained and the experience of the staff that can be made available within the necessary time period. Wherever possible, specific advice should be obtained from persons experienced in undertaking allied work in similar situations.

Special Note Regarding Cost Estimates

Prices have been included in this paper only to give very rough approximations of the relative costs for the different kinds of items referred to. These costs have been estimated only on a basis of the catalogued prices of the items referred to at the time of the Consultation (i.e. October 1975) and these may vary quite widely according to the suppliers and to the particular models chosen. No allowances have been made for inflationary increases or for delivery charges which may sometimes be heavy. In these circumstances, it must be emphasized that new and specific budget estimates should be made before embarking on project activities. High contingency allowances should also be built into such estimates particularly if the activity is to be undertaken in a location where similar work has not been carried out previously.

STAGE 1. TO PRODUCE QUALITATIVE AND SEMI-QUANTITATIVE DATA ON ORGANOCHLORINES AND SPECIFIC ORGANOPHOSPHOROUS PESTICIDES

Such a facility would not be adequate for general monitoring of residues (e.g. in foods). It would be more suitable where a single kind of analysis is to be performed; as, for example in investigating the fate of a pesticide used for a particular purpose.

Staff: 1 competent analyst together with adequate junior staff

Accommodation: A minimum of 1 office and 2 laboratory rooms (one for preparation of the samples, one for analyses). Each minimum size 4 X 4 m., equipped with hot and cold water, sink and drainage board; at least 6 electric points (earthed). Store room: at least 3 X 3 m. A fume cupboard or other forced draft ventilation is needed, especially for the thin layer work and for processes of solvent purification.

Equipment:

Basic laboratory items

Balances (coarse, laboratory, and analytical)
Drying oven
Homogenizer, blender and grinder
Rotary evaporator
Water distillation unit
Heating mantles
Refrigerators (2)
Deep freezer

Total Ca. $ 5,000

Specialized analytical equipment

Sets of thin layer chromatographic (TLC) equipment (including pre-coated plates, developing tanks, spotting equipment)
Ultra-violet lamp (254 and 356 mμ) and/or UV viewing cabinet

Total Ca. $ 3,000

Glassware

A full range of beakers, pipettes, volumetric and measuring flasks (e.g. volumetric flasks from 2 ml to 1 l)
Reagent tubes
Calibrated centrifuge tubes
Pipetting flasks
Soxhlets in various sizes
A full range of Quickfit or equivalent for distilling and extraction procedures
Chromatographic columns for cleanup processes
Separating funnels, conical flasks, measuring cylinders, glass stoppered tubes (15-50/ ml)

Total Ca. $ 4,000

Solvents

Acetone (250 l), hexane (200 l), ethanol (100 l)
Methanol (100 l)
Acetonitrile (50 l)

Total Ca. $ 4,000

General Chemicals — Total Ca. $ 2,000

Analytical Chemistry Reference Works and Journals — Total Ca. $ 1,000

GRAND TOTAL (Stage 1) Ca. $19,000

STAGE 2. TO PRODUCE QUALITATIVE AND QUANTITATIVE DATA ON ORGANOCHLORINES AND ORGANOPHOSPHOROUS PESTICIDES

Staff: As in Stage 1

Accommodation: As in Stage 1

Equipment:

Basic laboratory equipment

As in Stage 1, plus:
Two all glass distillation units (10-12 litre capacity) for purification of solvents
Vacuum pump of some kind (water or electricity)
Rotary compressor
Centrifuge
Ultrasonic bath
Spectrophotometer (may sometimes be used as an alternative to TLC)
Depending on the intended capacity, additional items may be needed

Total Ca. $ 7,500

Specialized analytical equipment

One dual channel gas/liquid chromatograph (GLC) or two single channel GLCs equipped with electrolytic conductivity/electron capture/alkali flame ionisation (EC/AFI) or flame photometric detectors, complete with recorders, spares and necessary columns (prepacked), control valves, tubing, gas filters, injection syringes, etc. Empty columns (preferably stainless steel) and support materials.

The choice of detectors for use with the GLC will depend on the range of pesticides to be studied. For example, although the electron capture detector is highly sensitive for organo-chloride compounds, it is nonspecific, and subject to many interferences and artifacts. In the hands of relatively untrained analysts it can lead to unvalidated claims of high residues. Its use often requires extensive cleanup with decrease in overall recovery. Where possible therefore one of the more specific detectors should be used.

When choosing between GLCs of different manufacture the ready availability of spare parts and servicing facilities in the particular locality should not be overlooked.

Gas/Liquid Chromatographs (GLC)	$20,000
Recorders - $1,500 each	3,000
Spares and accessories	10,000

Total Ca. $33,000

Gas supplies are essential and are normally obtained separately. Cylinders may have to be brought from sources far away and after being used sent for refilling. Costs are difficult to assess and may vary considerably depending on the location of the laboratory in relation to nearest gas supplier.

In some localities where supplies of pure gases may have to be brought from long distances, it is worthwhile to add gas purification and drying equipment in the inventory, thereby permitting the use of "commercial grade" supplies of gas that are more readily available.

Nitrogen 4 cylinders Hydrogen 4 cylinders Compressed air. The locally available quality is often satisfactory.	Total Ca.	$ 3,000
Set of Thin Layer Chromatographic (TLC) equipment Reflectometer unit and recorder	Total	$ 1,000
Glassware cf. Basic Laboratory Equipment		$ 4,000
Solvents cf. Basic Laboratory Equipment		$ 4,000
Chemicals cf. Basic Laboratory Equipment		$ 4,000
Reference Works and Journals		$ 1,500

GRAND TOTAL (Stage 2) Ca. $58,000

STAGE 3. TO INCREASE THE CAPACITY OF PROCESSING SAMPLES FOR PESTICIDE RESIDUE ANALYSIS AND TO INCLUDE THE DETERMINATION OF RESIDUES IN FOODS

Staff: Two competent analysts together with adequate junior staff

Accommodation: 3 or more laboratory rooms; 2 offices; 2 store rooms

Equipment:

Basic laboratory equipment As in Stage 2; most of the items have however to be purchased in larger quantities	Total	$15,000
Specialized analytical equipment 3-4 GLCs complete with detectors (EC, AFI, FI) and recorders, spares and accessories. Gases	Total	$70,000
TLC equipment	Total	$10,000
Glassware cf. Basic laboratory equipment		$ 8,000
Solvents cf. Basic laboratory equipment		$ 8,000
Chemicals cf. Basic laboratory equipment		$10,000
Reference works and journals		$ 2,000

GRAND TOTAL (Stage 3) Ca. $123,000

RUNNING COSTS

Once the laboratory has been established as outlined in Stages 1,2 or 3, money must be available to cover the running costs, of which part will be in overseas expenditure. The running costs do not include salaries, rents, etc. or basic maintenance of the laboratory facilities.

Because of the greater capacity and sophisticated equipment in laboratories equipped according to Stage 2 or 3, the running costs of these are considerably greater than compared to a laboratory of Stage 1. On a yearly basis, the running costs for a Stage 1 laboratory is estimated at not less than $3,000, Stage 2, $6,000 and Stage 3, $10,000.

Special Requirements

Laboratories being established in certain places may have special needs e.g. air conditioners, voltage stabilizers, etc.

MR/H6665/E/2.76/1/2500