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REPORT ON A VISIT TO THE PESTICIDE RESIDUE LABORATORY OF THE PLANT PROTECTION DEPARTMENT, MINISTRY OF AGRICULTURE, WAD MEDANI, SUDAN

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J COX

Tropical Development and Research Institute
Storage Department
London Road
Slough,
Berks. SL3 7HL, U.K.

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1. INTRODUCTION

1.1 Hunting Technical Services, in association with the Tropical Development and Research Institute, have been engaged by Kreditanstalt für Wiederaufbau (KFW), West German Government, as consultants to monitor the application of pesticides to cotton in 1985-86 for which a grant of DM 140 million, covering the cost of all materials, plus monitoring costs, is being provided. The monitoring programme is to cover the delivery and storage of pesticides, the application of air-sprayed insecticides and the hazard to field workers, operators and village dwellers, and the hazard to the environment as far as this can be ascertained in a short-term project. The methodology for the assessment is varied (Annex 1) with, for example, the hazard to field workers, operators and village dwellers being monitored by the weekly checking of blood cholinesterase levels. Other aspects, such as the monitoring of spray drift and the assessment of environmental hazard will require chemical analysis and it was suggested that the Pesticide Laboratory of the Plant Protection Department, Ministry of Agriculture, Wad Medani, might be able to undertake the analyses.

1.2 Indeed, during initial discussions in mid-June, the consultants were pressed by KFW and the Sudanese Government delegation to make maximum use of the laboratory facilities at Wad Medani. In late July, the Team Leader contacted the GTZ Project Supervisor, Dr Bossi of Darmstadt Laboratories, who was also optimistic regarding the laboratory's capabilities. However, during the formal briefing of the Team Leader on 12 August, Dr Bossi stated that he had since learnt from a colleague who had visited the laboratory early in 1985 that the situation regarding both morale and technical expertise was poor and Dr Bossi withdrew his recommendation that the laboratory be used by the monitoring project. Dr Bossi then suggested that Darmstadt might undertake the work, but he subsequently advised that it was beyond their capability. TDRI, as specialist advisers to the monitoring project, was then requested to provide assistance in the assessment of the ability of the laboratory to undertake the complex programme. A list of the pesticides to be used is at Annex 2.

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2. THE PESTICIDE RESIDUE LABORATORY OF THE PLANT PROTECTION DEPARTMENT, MINISTRY OF AGRICULTURE, WAD MEDANI.

2.1 The laboratory was established in 1967 by the German Aid Agency GTZ and still receives some limited support from that source. There is a staff of 12 graduate chemists headed by Mr S I Shabaan, and one technician. The length of service and experience of the staff varies considerably, although Mr Shabaan has been there, and involved in residue analysis, since 1974. The bulk of the previous work of the laboratory has been on the extraction and analysis of chlorinated insecticide residues with only a little work on other compounds such as Aldicarb and Dimethoate, although in the latter case this was some years ago. Work on phosphorus, sulphur and nitrogen-containing compounds has been severely restricted because of malfunctions in two of the gas liquid chromatographic detection systems. These detectors (flame photometric and thermionic) have recently been sent to Germany for servicing, and it is understood that these will not be returned before October at the earliest. The laboratory staff are therefore by and large unfamiliar with the operations of these systems.

2.2 The laboratory facilities are basic and rather elderly with the main analytical instruments being three Carlo Erber gas liquid chromatographs, each fitted with electron capture detectors, in addition to the two detectors mentioned earlier. The instruments were not in use at the time of my visit, and I was not able to assess their condition although I was assured that they were in working order.

2.3 Supplies of glassware seemed limited, but more can be borrowed from the unused stocks in the formulation laboratory. All solvents and general reagents have to be imported from the UK or Germany as have supplies of pure nitrogen for the glc's (hydrogen and air are available locally). Some consumables are available, on a return basis, although their ultimate replacement must be carefully planned if delays in supply are to be avoided or minimised.

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2.4 Water supplies to the laboratory are good and there is a large reserve tank. Within the laboratory the supply is pressurised by pump and is adequate, for example, to enable the use of water-vacuum pumps. Gas supplies. e.g. compressed air and nitrogen, are only available from cylinders. The electricity supply is a problem in that although the voltage of the supply to the gas chromatographs is stabilised (220V), the supply is itself prone to interruption which can lead to considerable 'down-time', particularly with the glc's which require a period of stabilisation. The problems with this aspect were, in fact, particularly stressed during discussions by Professor Zorgani of the co-located Agricultural Research Corporation (ARC), who has been involved in similar residue work for many years.

2.5 The staff of the laboratory seem generally well-read on their subject and a number of reference books are available in the laboratory, although a few of these are rather elderly. Additionally, the staff have access to the ARC Library, which is reasonably well stocked. Relations with the ARC and with the University of the Gezira (in Wad Medani) seem reasonable and the laboratory has made use of their facilities on occasion.

2.6 There is, however, a rather unprofessional air about the laboratory which manifests itself in different ways - it is disorganised, untidy and dirty. Similarly, a number of the few visible working practices (storage of reference standards and solutions, the keeping of laboratory records and the absence, although they were available, of molecular sieves on the gas supply lines of the glc's) were open to question and indicated a lack of appreciation of the required procedures. I understand that, in the past, the timekeeping and morale of the staff has been questioned and there does appear to be a problem in this respect. In part this attitude may be conditioned by the apparent shortage of work for the laboratory, inducing a lack of direction and motivation. It could be expected of a laboratory that was aware of the possibility of becoming directly involved in a major sampling programme of the nature

proposed to undertake some research and to practice the techniques with which it was unfamiliar, even if the final programme was not agreed. This does not appear to be happening and whilst allowing for the fact that two important glc detectors are out of commission and allowing for possible restrictions on consumables, there is scope for this work to have been started. A laboratory, irrespective of its discipline or sphere of activity, will inevitably use to its advantage any 'quiet periods' in order to research or develop laboratory techniques, but this does not appear to be the case with this laboratory. I would therefore question its professionalism, its motivation and its direction. A degree of sympathy must be felt for the laboratory staff who genuinely appear both embarrassed and disillusioned.

2.7 I was disappointed by the attitude of Mr Shaaban who, after initially welcoming my visit, provided little cooperation and does not seem to have attempted, to date, to accommodate the needs of the project. The position was complicated by Mr Shaaban being on leave at the time of my visit and the assurances of his senior staff that he would be available to me were not met. Yet I understood that when the Project Team Leader initiated the suggestion of a visit by a Pesticide Specialist, specifically during the first half of September, Mr Shaaban had welcomed this suggestion.

3. OTHER CONSIDERATIONS

3.1 In assessing the laboratory, I have also given thought to the nature of the analytical programme and the implications for the scope of that programme should it not be possible to undertake the work at Wad Medani which, prima facie, would appear to be the most practical option. This would ensure the minimum time between the actual sampling and the extraction and/or analysis and would also mean that the results would be more readily accessible to the study team. The problems of transporting samples to the UK, or elsewhere, in their original form, or as extracts, would be avoided as would be

the need to review the scope of the sampling programme in view of the potential difficulties with the taking and transportation of water samples. However, this latter option may now have to be explored and, in particular, the use of personnel returning to the UK as bearers of samples.

3.2 Some general information was requested as to the procedures to be used in the collection of soil and water samples and the information provided is given in Annex 3. Some information regarding the extraction of water samples was also provided.

4. RECOMMENDATIONS

4.1 It is my opinion that the ability of the laboratory at Wad Medani to undertake an analytical programme of this complexity is not proven and for them to do so without external monitoring would be a risk, posing questions as to the validity of the results. The following options are available and are placed in order of recommendation:

4.2 Option 1

The Plant Protection Laboratory at Wad Medani should undertake the analytical programme under the guidance of an expert analyst who would visit the laboratory for a period of 6-8 weeks once the sampling programme had commenced. The laboratory should receive a detailed breakdown of the requirements in terms of the number and nature of the samples to be analysed, and be charged with the responsibility for obtaining the necessary apparatus, reagents, gas supplies, etc., to undertake the work.

Annex 1 provides some preliminary information on the sampling programme presently envisaged. Preliminary investigations of the methods of analysis should be made and practised, and the working conditions of the glc's checked before the programme commences; it is essential that all the facilities are ready before the arrival of the expert. A senior Sudanese representative should be charged with ensuring that the laboratory and its management complies with the above. In view of the past association of GTZ with this

laboratory, it may be appropriate for that organisation to be invited to supply the expert analyst.

4.3 Option 2

The samples would be sent to a suitable laboratory overseas for analysis. The difficulties of this approach have been discussed elsewhere. If water samples were still to be included in the monitoring programme, then there would still be a need to use local laboratory facilities to prepare extracts for transportation. Arrangements would have to be made for the samples to be carried by individuals or for full details of flights, airwaybill numbers, etc., to be sent to the recipient laboratory so that they could arrange prompt collection of the samples, if they were to be sent independently.

4.4 Option 1 would be of dual benefit in that the laboratory would have the opportunity of extending its experience by examining this wide range of pesticides with the assistance, where required, of an expert analyst. The delay in the return of the glc detection systems may, however, affect the viability of this option and may force the analyses to be conducted elsewhere. The extent of the delay must be carefully ascertained; this would probably best be handled by Hunting Technical Services via the GTZ Office in Khartoum

4.5 The present commitments on TDRI prevent the provision of an expert for attachment to the laboratory at Wad Medani and also preclude undertaking the analysis of the samples from the monitoring programme. If Option 2 is ultimately adopted, then either GTZ must be approached to see whether Darmstadt will reconsider their position and take on the programme or a qualified commercial laboratory such as Huntington Research Centre would have to be used.

ACKNOWLEDGEMENTS

I would like to thank the Team Leader, Mr J E Moore, for his time and trouble in arranging my programme.

ANNEX 1

ASSESSMENT METHODOLOGY, SAMPLING PROCEDURES AND NUMBERS

In view of the enormous areas concerned, efforts will be concentrated on the four major irrigated agricultural corporations (schemes) Gezira, Rahad, White Nile, New Halfa, whereas the other two schemes (Blue Nile and Suki) being close to the Gezira will receive intermittent attention. The Project will be coordinated from Gezira, operating from Wad Medani, to provide close contact with both the Gezira Board and with the Agricultural Research Station.

At this stage, and pending receipt of details of the 1985 Crop Protection and Spray policy detailing the pesticides ordered, only a guideline of methdology to be used can be given, together with an indication of sampling procedures and numbers of samples anticipated for provision of the required data.

A. **BASIC MONITORING**

1. Delivery and Storage

Inspections will be made at random intervals of all the Production Corporation chemicals stores to ascertain storage conditions, controls, condition of drums, temperatures at which chemicals are stored. If damage is discovered efforts will be made to ascertain where this occurred and, in the case of leakage, whether any safety hazard resulted. It is anticipated that substantial quantities of product will be liable to late delivery to Port Sudan. In event of further delay in transit from port to the corporation, attempts will be made to ascertain reasons and to expedite transportation (customs delay, availability of vehicles, hold up due to famine relief action, labour shortage, etc.). The collaboration of all Sudanese organisations involved will be expected, together with that of the commercial concerns supplying the pesticides.

2. Airstrip Facilities

The number of spray contractors, base airstrip and field airstrips will be ascertained. Facilities and procedures will be checked (loading equipment, pumps, spillage, mixing, water supplies) safety procedures (protective clothing, washing facilities, number hours continual exposure, number of days continual work) will be reviewed.

Blood cholinesterase levels will be monitored on a weekly sampling basis at each (assume 5 sites)

3 + 2 Pilot/Mechanics
2 + 3 Loaders/Cleaners
10

No. of samples: 5 sites x 10 persons x 16 weeks = 800

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N.B. Cholinesterase monitoring would be using the simple, proven Lovibond Field Kit. While endosulfan is the main insecticide used on Sudanese cotton it is nearly always sprayed mixed with organo-phosphorus insecticides and thus the total quantity of endosulfan absorbed may be indicated, although information on cumulative absorption levels will not be obtained. Chemical analyses of blood would also be taken to correlate the Lovibond data with true chemical content, if considered necessary (Ref. 4.2). If application of the formamidine insecticide amitraz (Mitac) is expected to be important, provision could be made to monitor absorption by urine analysis.

Specialist advice was that analysis was valuless since results cannot be related to degree of contamination.

3. Application

3.1 Soil Applied Insecticides/Herbicides

Survey of application methodology for Temik granules (Gezira/Rahad) applied post-planting, about 6-8 weeks.

Blood sampling of workers over six week period:

5 Drivers
5 Loaders
10

No. samples: 2 sites x 10 persons x 3 weeks = 60.

Compliance with S.G.B. regulations will be assessed and whether there are any failures to follow the conditions of contracts. Application of herbicides cannot be fully monitored, as used at planting.

3.2 Airpsrayed Insecticides

Basic monitoring would be carried out on Rahad, New Halfa and White Nile, while in-depth assessment would be on two sites in the Gezira (Ref. below under B). Weather conditions would be monitored as far as possible within the constraints of available meteorological stations. Three sprays (Early ULV, Mid EC high vol., Late EC lower vol.) should be monitored for basic information.

(i) Monitoring would include assessment of spray contractors, compliance with conditions of Spray contract, e.g. continuous spraying after conditions are unsatisfactory (temp., winds), overspraying canals, dumping of insecticide etc., "stripey" spraying, need for flagmen, warning of farmers.

(ii) Chemical Sampling: Collectors would be sited on open ground down-wind of sprayed fields at 50m intervals for 500m. The collectors would be synthetic 'angora' wool, 5 x 1m lengths, as TDRI recommendation. Collectors of about 1.5m will be stretched between two strings attached to ½in. iron rods driven vertically, into the ground.

Alternatively, field crops of groundnuts, cereals or sorghum could be utilised. Collectors would be placed at different heights at each station.

3 sites x 3 sprays x 11 stations (x 5 collectors) = 99 samples (GLC analysis)
3 sites x 3 sprays x 11 stations (x 1 paper) = 99 samples (oil or water sensitive)

(iii) Blood sampling. Field assessment staff and workers would be checked for blood cholinesterase levels on a weekly basis.

3 Field Scouts
2 Field Supervisors
5 Labourers/Farmers
10

a) No. of samples:
2 sites x 20 persons x 20 weeks = 400 Schemes with no Temik
b) 2 x 2 sites x 10 persons x 20 weeks = 800 Temik Schemes - Gezira/Rahad (Ref. 4.2)
1200

a) New Halfa/White Nile
b) ± Temik 2 sites each Rahad/Gezira.

(iv) Monitoring Pest Scouting. An attempt will be made to ascertain what constraints there are adversely affecting the scouting programme, e.g. availability of transport, number of persons needed, training programmes, etc. Since scouting is the fundamental prerequisite to spraying according to an Integrated Pest Management programme, an attempt will be made to ascertain its benefit by pinpointing breakdowns in the scouting programme (which are sometimes quite unavoidable) and assessing effects of such a breakdown in terms of yield, or additional sprays needed. An economic evaluation may be possible where circumstances and data collected permit.

B. ASSESSMENT OF ENVIRONMENTAL HAZARD
Revised according to Application Specialist's recommendation.

This would be carried out over two months on two (possibly one if limited by circumstances) cotton blocks in Gezira, possibly involving 5 sprays.

4. Drift Hazard

4.1 An intensive investigation would be made to measure the proportions of known quantities of sprayed insecticides that were deposited. If possible one pair of sprays on the same day will be monitored, before 8.30 a.m. and after 11 a.m.

(i) on foliage within the sprayed field (4 collecting surfaces) x 4 heights x 21 stations x 5 sprays x 2 sites = (4) x 840 = 3360 samples.

(ii) on soil within the sprayed field.

(iii) outside the sprayed field on soil surface or vegetation within 0.5 kilometre distance, dispersed through the atmosphere.

Note: (iii) a) Rotary samplers at 10, 20, 50, 100, 200, 500m + paper or MgO2 slides at all 6 stations (6 + 6 = 12) x 5 sprays x 2 sites = 120.

b) Chemical samples (field edge to 500m downwind at intervals of 20, 50, 100, 200, 500m)
5 collectors x 1m lengths x 5 stations x 5 sprays x 2 sites = 50 samples (duplicated for UK analysis).

Plant samples: 10 whole plants within selected field, 6 outside field.

10 x 5 x 2 = 100
6 x 5 x 2 = 60

Soil surface samples: 10 stations in selected fields, 6 stations outside field. These are optional at Specialist's discretion:

10 x 5 x 2 = 100
6 x 5 x 2 = 60

The selected sites would have to be downwind of a cotton block with an area of fallow or other crop adjacent. Differences due to time of spraying during the day are expected to be greater than seasonal time difference.

4.2 Blood samples of field assessment staff and workers would be assessed, as under 3.2 (iii).

It is planned that these collaborators would provide the samples for chemical pesticide analysis (Ref. 2 above). (Cancelled ref. 2 above).

5. Hazard - Village Inhabitants

The effect of spraying on the blood cholinesterase enzyme levels of the local population would be monitored by taking blood samples on a weekly basis (as 2 above). Collaborating villagers selected would be persons not normally going to work in cotton fields. (Gezira only.)

10 women
5 village dwellers
5 herdsmen
20

20 persons x 20 weeks x 1 site = 400 Temik + area)
20 persons x 20 weeks x 1 site = 400 Temik - area)

Food samples would be taken if considered appropriate. These samples would be taken in a village 1-2 km downwind of a sprayed field and the same day as spraying:

5 samples grain-meal
5 samples green vegetables.

6. Residue Hazard

Soil samples will be taken from fields in the selected cotton blocks before the spray season starts, at the end of the two month study period, and at the end of the project in February 1986. If possible, fields selected will be the same as those used for 4 above and soil would be collected from the same stations. Samples would be taken at three depths to assess the degree to which pesticides are leached downward under irrigation (0.3cm: 3-10cm: 10-20cm).

No. of samples: 3 depths x 10 stations x 3 dates x 2 sites = 180.

7. Water Pollution

Assessment of hazard through the pollution of water in canals will be limited to consideration of direct pollution by overspraying. Water samples will be taken from canals near villages in the selected areas and analysed for pesticide content at the Wad Medani Station Laboratories.

No. of samples: 2 sites x 4 canals x 30 weeks = 240.

8. Effect on Beneficial Insect Populations

The effect of different insecticides on the populations of beneficial insects will be assessed by carrying out sweep net sampling, or suction sampling, on cotton before and after spraying. Standard procedures will be adopted when carrying this out. Identifications will be made in the Entomological Laboratory at Wad Medani.

ANNEX 2

PESTICIDES SCHEDULED FOR USE BY THE GEZIRA BOARD: SEASON 1985/86

a) Organophosphorus compounds

Chlorpyrifos
Chlorfenvinphos
Dicrotophos
Dimethoate
Profenophos
Prothoate
Thiometon

b) Synthetic pyrethroids

Cypermethrin
Deltamethrin
Fenvalerate

c) Chlorinated

Endosulfan

d) Carbamates

Aldicarb
Methomyl

e) Others

Amitraz

ANNEX 3

Pesticide Residues in Soil

Samples:

The field soil samples from the chosen sites (as yet undetermined) should be wrapped in clean aluminium foil immediately after collection.

The sample size should be large enough to be representative of the sampling site. Two approaches can be adopted:

1. A number of soil cores can be taken from the site area which can then be cut into the desired depth layers (0.3cm, 3-10cm and 10-20cm). The layer samples can then be bulked to give a composite for each depth.

2. An area, perhaps 1 foot square, can be measured and the soil removed from that area to the required depth. The layers can be removed sequentially. In practice this may be more difficult than the removal of cores using a metal tube.

The final composite sample must be well mixed so that the sample for submission to the laboratory is truly representative. This sample should normally be of about 500g with a minimum of 250g.

The samples must be chilled immediately after collection and, preferably, deep frozen. The samples must be kept deep-frozen whilst awaiting analysis. The period between collection and extraction must be kept to a minimum to reduce the possibility of the deterioration of residues. If delays in the analysis are foreseen, then the samples should be extracted and the extracts stored in the deep-freeze whilst awaiting clean-up/residue determination. The residues will be more stable in the extract form.

Pesticide Residues in Water

Samples:

Volume required for analysis will be 1000 ml (minimum). Sample origin will depend on the object of the exercise. It is assumed that they will be 'grab' samples to determine the average content of the water and not to determine areas of higher contamination, e.g. inlets from drainage gulleys, etc. It may be appropriate to make a composite sample from 3 or 4 gallon samples.

The sample container should be glass (wide-necked preferably, but not essential). It should be clean and preferably solvent-washed prior to use. Extraction of the sample must take place as soon as is practicable because of the risk of pesticide degradation. As a last resort and possibly as a reserve, a volume could be frozen in a polythene container although under normal circumstances sample contact with plastic/polythene is to be avoided.

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Extraction and analysis:

Extraction will be by partition into organic solvent. Some procedures are available for absorption from water onto a solid (e.g. carbon) but these do not reflect the range of analyses required here.

The current method of the USA EPA (Environmental Protection Agency) is as follows:

1. Take 1 litre of water and add 75 ml of dichloromethane. Add 20g of anhydrous sodium sulphate and shake immediately for two minutes. Allow the layers to separate. (2 litre separating funnel required.)

2. Prepare a glass column (approx. 300 mm and 25mm i.d.) containing 5cm of anyhydrous sodium sulphate.

3. Run the dichloromethane (lower) layer from the separating funnel through the column containing sodium sulphate. Collect the eluate in a 250 ml round-bottomed flask.

4. Repeat the extraction of water with a further 75 ml of dichloromethane, shaking for two minutes. (Add no more sodium sulphate). Allow the layers to separate and run the dichloromethane extract through the column, collecting the eluate in the same flask.

5. Rinse the sodium sulphate column with 20 ml dichloromethane collecting the washings in the flask.

6. Add 1 ml of 1% propylene glycol in acetone to the flask (or, as an alternative 1% liquid paraffin in hexane) and evaporate on a rotary vacuum evaporator at 35°C to a volume of 3-4 mls.

7. This extract is ready for analysis. However, if it is to be stored or prepared for transit to the UK the extract must be transferred to a strong, graduated glass stoppered test-tube or a volumetric flask or a suitable screw-capped bottle (e.g. McCartney bottle). For transit, the solvent must be carefully evaported off (preferably under a stream of nitrogen - not air) and the container sealed. If a screw-cap bottle is used, an aluminium foil or teflon liner must be used inside the screw cap.

This method has been evaluated for a range of organo-chlorine and organo-phosphorus pesticides. There is no data available for the synthetic pyrethroids and although the procedure should work, laboratory confirmation would be required. if the procedure is unsatisfactory for the pyrethroids, there is a specific procedure which could be adopted and it is detailed below. This would involve, however, extraction of a separate water sample.

Annex 3 contd.

Extraction and analysis:

Extraction will be by partition into organic solvent. Some procedures are available for absorption from water onto a solid (e.g. carbon) but these do not reflect the range of analyses required here.

The current method of the USA EPA (Environmental Protection Agency) is as follows:

1. Take 1 litre of water and add 75 ml of dichloromethane. Add 20g of anhydrous sodium sulphate and shake immediately for two minutes. Allow the layers to separate. (2 litre separating funnel required.)

2. Prepare a glass column (approx. 300 mm and 25mm i.d.) containing 5cm of anhydrous sodium sulphate.

3. Run the dichloromethane (lower) layer from the separating funnel through the column containing sodium sulphate. Collect the eluate in a 250 ml round-bottomed flask.

4. Repeat the extraction of water with a further 75 ml of dichloromethane, shaking for two minutes. (Add no more sodium sulphate). Allow the layers to separate and run the dichloromethane extract through the column, collecting the eluate in the same flask.

5. Rinse the sodium sulphate column with 20 ml dichloromethane collecting the washings in the flask.

6. Add 1 ml of 1% propylene glycol in acetone to the flask (or, as an alternative 1% liquid paraffin in hexane) and evaporate on a rotary vacuum evaporator at 35°C to a volume of 3-4 mls.

7. This extract is ready for analysis. However, if it is to be stored or prepared for transit to the UK the extract must be transferred to a strong, graduated glass stoppered test-tube or a volumetric flask or a suitable screw-capped bottle (e.g. McCartney bottle). For transit, the solvent must be carefully evaporated off (preferably under a stream of nitrogen - not air) and the container sealed. If a screw-cap bottle is used, an aluminium foil or teflon liner must be used inside the screw cap.

This method has been evaluated for a range of organo-chlorine and organo-phosphorus pesticides. There is no data available for the synthetic pyrethroids and although the procedure should work, laboratory confirmation would be required. If the procedure is unsatisfactory for the pyrethroids, there is a specific procedure which could be adopted and it is detailed below. This would involve, however, extraction of a separate water sample.

Additionally, the 'recovery' of the dimethoate and dicrotophos by the EPA procedure is low and modification may be necessary. However, this can probably be accomplished by changing the solvent (from dichloromethane to chloroform or perhaps ethyl acetate) or by changing the volumes and thereby the aqueous/solvent ratio (from 1000 ml v. 75 ml to say 1000 ml v 50 ml). A further approach would be to increase the salt content from 2% (20g/1000 ml) to 5% or 10%. Such modifications are relatively simple to evaluate in the laboratory.

Water extraction procedure for synthetic pyrethroids

1. Add 1g sodium chloride to 50g (50ml) of sample. Add 50 ml n-hexane and shake for one minute. Allow the layers to separate.

2. Prepare a chromatographic column (300 mm x 25 mm i.d.) containing 5 cm anhydrous sodium sulphate.

3. Run the hexane extract through the column and collect the eluate in a 250 ml flask.

4. Repeat the extraction of the water twice more, each time running the hexane extracts through the sodium sulphate column.

5. Rinse the column with 20 ml hexane and combine the washings with the dried extract in the 250 ml flask.

6. Add 1 ml of 1% propylene glycol in acetone (or 1% liquid paraffin in hexane) and concentrate to 2-3 mls on a rotary vacuum evaporator at 35°C. Adjust the volume for glc analysis or transfer for storage/transit as detailed earlier.