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ESTABLISHMENT OF A PILOT PLANT FOR PESTICIDE FORMULATION

DP/MYA/80/011

UNION OF MYANMAR

Technical report: Findings and recommendations*

Prepared for the Government of the Union of Myanmar
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Keith S Johnson,
consultant in pesticide formulation technology

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Vienna

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* This document has not been edited.

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Explanatory Notes on Abbreviations Used

UNDP	:	United Nations Development Programme
UNIDO	:	United Nations Industrial Development Organisation
MAS	:	Myanmar Agricultural Services Ltd
MPI	:	Myanmar Pharmaceutical Industries Ltd
GLC	:	Gas Liquid Chromatograph
EC	:	Electron Capture Detector
FID	:	Flame Ionization Detector
HPLC	:	High Pressure Liquid Chromatography

1. SUMMARY

An Environmental, Health and Safety Survey was conducted at the Myanmar Pharmaceutical Industry Pesticide Pilot Plant during the period 14 - 27 November 1991.

The Plant, which has been operational for some eighteen months is still on the stages of development and expansion.

A range of modifications and ongoing improvements to environmental/safety controls are identified and recommended to ensure full compliance with high standards in the future.

An important and urgent requirement is the appointment from the existing management or supervisory staff a part-time Environmental/Safety Officer to integrate and implement controls at workplace level.

Site effluents, currently not treated must be fully detoxified before disposal.

The acquisition of package effluent treatment plant is recommended. Proposals for future treated effluent quality standards are given with identified needs for analytical resources and methodology. Disposal outlets for final treated effluent and sludge residues are also identified.

The current state of waste arisings on-site is reviewed and classified.

In the absence of any acceptable off-site or Government-owned resources for toxic waste disposal, In-house recycling, treatment and secure storage of wastes are discussed, along with the need for accurate waste classification, labelling and records.

Current efforts on waste recycling and minimisation are recognised and commended.

Recommendations are given for further In-house initiatives including waste composting and high temperature incineration as a move to self-sufficiency for on-site waste disposal.

Resulting from earlier surveys, safety hygiene programmes have been initiated. Acknowledging progress to date, further improvements will be necessary on an on-going basis.

Manufacturing plant is well-contained and extracted to control fume vapour and contact exposure risk. Faults in product filling line, causing gross spillage of toxic products migrating beyond existing protective measures into the workplace, are a cause for concern and require urgent remediation.

The use of issued protective clothing and safety equipment in areas of exposure risk during process and filling operations is inconsistent and requires more strict supervision by plant management.

SUMMARY (continued)

Similarly, plant housekeeping could be improved with more frequent clean-up of spillage residues, removal of wastes and the avoidance of stock accumulation, packages, etc, in the formulation areas.

The need for atmospheric monitoring is discussed in the light of existing in-built extraction provisions, and recommendations are given for the acquisition of static vapour measurement equipment essentially to monitor both plant and laboratory atmospheres.

Current measures involving the blood sampling and testing of cholinesterase activity of operators working with organo-phosphates is reviewed; reference to the value of such tests at six month intervals, and problems of time-lag incurred with off-site analysis is discussed. Possible benefits of alternative, more regular on-site assay of cholinesterase activity is proposed with suitable methodology given.

The storage of larger quantities of Xylene solvent in drums within a warehouse is discussed with particular reference to operator injury risk. Solvent spillage and fire hazard recommendations for improved handling facilities and storage are given.

Fire prevention and control facilities on-site are inadequate. Delivery of a fire-tender is awaited. A larger water storage reservoir is needed to service this appliance.

Provision is necessary to contain all contaminated fire waters on-site along with a storage facility to hold these for treatment.

Rampant weed growth on underdeveloped areas of the site is unsightly and constitutes a fire risk. A regular grass-cutting and landscaping programme is recommended.

Public relations communications are maintained between the site and a small committee from the local community. Only one complaint, involving smoke and fume from burning activities on-site, has been registered.

The state of the un-made road to the plant, particularly in the wet season, is a cause for real concern. Accidental spillage of chemicals from vehicles is a potential hazard and pollution risk. Pressures on the authorities to improve the road surface must be vigorously pursued.

An account is given of the current status of production manufacture quality control which is proceeding satisfactorily.

Laboratory facilities were inspected and recommendations for additional resources, particularly environmental analysis are given.

Finally, an account is given on three training courses provided to line management covering environmental, health and safety aspects related to the formulation of pesticides.

2. RECOMMENDATIONS AND ACTIONS - SUMMARY

2.1 Effluent Treatment and Disposal

Actions for UNIDO:

2.1.1 Effluent Treatment -
Provide a Sentinel/Carbo-Flo MKII Effluent Treatment Plant (with adequate supplies of treated chemicals and adsorbents as indicated) to treat all site aqueous toxic effluents.

2.1.2 Advise and assist with the up-grade of analytical equipment and methodology to monitor quality of treated effluents for residual organics and pesticides.

Actions for MPI:

2.1.3 Install a new central effluent collection and treatment system within a new waste treatment and storage area.

2.1.4 Modify existing effluent collection - evaporation vessel for:

i. collection of contaminated effluents for treatment,

ii. storage of final treated effluents awaiting quality check and disposal,

iii. cover tanks with sliding rigid plastic screens.

2.1.5 Modify similarly the laboratory collection - evaporation vessel for effluent collection and storage only.

Make provision for the transfer of collected effluents (initially by tank) to the main central effluent plant for treatment.

2.1.6 Obtain water sprinkler - irrigation equipment to dispose of treated effluent on-site to grassland.

2.1.7 Sludge Disposal. Ensure dewatered sludges are securely stored, within polythene over-packs in steel drums and labelled, to await storage as toxic wastes.

2.2 Waste Disposal

Actions for UNIDO:

2.2.1 Provide a proprietary drum-crushing unit capable of crushing drums of up to 200 litres capacity.

2.2.2 Consider the acquisition of a high-temperature waste incinerator package unit (Ref. 4 and 5).

Actions for MPI:

2.2.3 Waste Management, Handling and Disposal - establish a site-system operated by designated site personnel and comprising:

2.2.3.1 Collection - provide colour coded waste receptacles in all work areas and laboratory.

2.2.3.2 Segregate wastes into specific types, label and where appropriate affix hazard warning labels.

2.2.3.3 Ensure all toxic wastes are securely packed into steel drums and labelled to await disposal.

2.2.3.4 Establish a secure dedicated waste handling and storage area in the south-west corner of the site, incorporating also the effluent treatment plant (Appendix I).

2.2.3.5 Enclose waste area with a security fence 2 metres high with double-gate access.

2.2.3.6 Prepare roadways and hardstanding in concrete and where appropriate bund to contain spillage.

2.2.3.7 Provide within the waste compound a roofed and well-ventilated area to store packaged wastes awaiting disposal.

2.2.3.8 Provide small office space within the roofed area for preparation of labels, documents and records for both wastes and effluents processed.

2.2.3.9 Ensure full records are maintained on all wastes produced and disposed of within- or off-site.

2.2.3.10 Waste Composting Treatment - Prepare a composting area within the waste compound in accordance with details in Appendix IV

2.2.3.11 Toxic Drum Disposal - All drums which have contained active pesticides must be decontaminated, punctured or crushed and disposed of to a steel smelter for scrap-metal recovery.

2.3. Industrial Hygiene/Safety

Actions for UNIDO:

2.3.1 Workplace Supervision and controls - Liaise with MPI on possible training of a Site Safety/Environmental Supervisor (proposed appointment). See also 2.3.3.

2.3.2 Atmospheric Monitoring - Consider the acquisition of vapour monitor to check workplace and laboratory atmosphere.

Actions for MPI:

2.3.3 Safety/Environment - Workplace Supervision and Controls. Appoint a responsible manager or superviser, initially on a part-time basis to supervise and implement controls at workplace level.

Training in these areas of control is essential and should include at least one visit to an established pesticide plant to gain experience.

2.3.4 Filling Line - Overhaul and adjust filling line equipment to eliminate spillage and product loss. Provide wash facility to clean contaminated bottles of filled product to packing into cartons.

2.3.5 Protective Clothing - All operators and maintenance staff must wear full protective clothing and eye protection when working with pesticides.

2.3.6 Housekeeping - Implement measures for daily cleaning of plant areas and equipment, including removal of wastes.

Unnecessary accumulation of raw materials, finished products and package materials in formulation and filling areas must be avoided.

2.3.7 Blood Cholinesterase Tests - Ensure all new employees receive three consecutive baseline tests before any workplace contact with O.P. compounds.

Consider adoption of on-site analysis, with higher frequency testing for blood cholinesterase checks on plant personnel.

2.3.8 Warehouse - Xylene Storage. Investigate the use of wooden pallets for safe movement, stacking and storage of drummed Xylene.

Explore the acquisition of a forklift 'drum-clamp' to facilitate safe-drum movement.

2.4. Fire Protection and Controls

2.4.1 Provide large water storage reservoir at least 150 cubic metres capacity.

2.4.2 Fit a lock-off gate valve into the main surface-water drain outfall pipe to contain fire run-off water.

2.4.3 Erect a dry bunded lagoon area in south west corner of the site to store contaminated fire water.

2.4.4 Regularly cut and remove grass and weed growth from undeveloped areas on-site to minimise fire risk.

2.5 Site Appearance

Initiate a programme of landscaping to improve overall site appearance.

2.6 Road Access

Maintain pressure on Government Authorities to improve the surface of the public access road to the site.

3. INTRODUCTION

3.1 Objective

The expert, in consultation with the project authorities, Myanmar Pharmaceutical Industries (MPI), will advise and assist with the overall management of Environmental, Health and Safety matters on-site with particular reference to:

- Treatment and disposal of liquid effluents.

- Handling, classification, storage and disposal of toxic and other waste materials.

- Review current occupational safety controls for operator exposure risk from toxins, fume, vapour and dust, both within the workplace and laboratory.

- Conduct training courses for site management on the broad aspects of environmental, health and safety controls necessary in a pesticide formulation plant.

- Discuss with management the current status and resources for analytical controls or product manufacture and environmental, health and safety monitoring.

3.2 Background

The pesticide pilot plant is situated at Hmawbi, 40 km north of Yangon.

Planning approval for the installation of a pesticide formulation plant to manufacture liquid and solid products was granted by the Myanmar Government in 1983.

Funded by UNDP, the factory was erected on a green fields site during 1984-1987.

Initially, only a liquids formulation plant, warehouses, laboratory and offices were completed. Future developments will include facilities for the formulation of powder and granule pesticide products.

The site currently occupies some 12.5 acres, is underdeveloped, but secure within a high perimeter fence with 24 hour security provisions.

MPI staff manning levels - MPI management, operational and casual workers amount to some 50 people working on a single day-shift basis.

Production of emulsion concentrate (EC) solvent-based products commenced in 1989.

The need was identified to ensure that all site-operations comply

fully with high standards of environmental, health and safety controls.

3.2.1 The purpose of the visit was to conduct a full assessment of site operations with particular reference to effluent treatment, waste disposal and occupational health requirements. Also, to provide to line management a broad basis of training in these areas of control.

During the same period 14 - 27 November 1991, a detailed site safety audit was conducted by DR M G Srivastava, Consultant to UNIDO, whose findings are the subject of a separate report.

3.3 Scope of the Report

This report addresses three main areas, with separate comments and recommendations:

i. Effluent treatment and Disposal

ii. Waste Disposal

iii. Industrial Hygiene and Safety.

Other site-related technical issues addressed during the visit are noted with comments and recommendations where appropriate.

A separate summary of recommendations and actions is also presented to assist with the progression and implementation of specific items identified.

4. EFFLUENT TREATMENT

4.1 Sources, Composition and Volume

Toxic aqueous effluents arise from a number of plant and site activities including:

- Plant cleaning, washdown, floor washing (spillages)
- Drum washing and de-contamination operations
- Exhausted liquors from vapour scrubbing unit
- Aqueous laboratory wastes
- Laundering of contaminated overalls and other protective clothing.

The effluents are toxic, for the most part alkaline, containing significant concentrations of residual pesticides, solvent and surfactants.

Current estimates of combined effluent arisings are small, amounting to some 300 to 500 litres per week. Volumes are likely to increase with future expansion of site manufacturing activity.

4.2 Effluent Disposal - Current Provisions

No effluent treatment or detoxification is at present attempted prior to disposal.

Contaminated effluents are discharged under gravity to a common drain in the emulsion concentrate (EC) plant, which discharges into a large concrete reception vessels situated at the south west corner of the site (Appendix I).

The tank is covered with an improvised plastic sheet (badly torn) to prevent ingress of rain water.

An accumulated volume in excess of 25 cubic metres of contaminated effluent and infiltration water awaits disposal.

Disposal is currently reliant upon solar evaporation to reduce the overall effluent with occasional removal of concentrated toxic residues with are currently stored in drums for disposal.

A similar, but smaller, evaporation basin is situated in the vicinity of the laboratory block for the collection and solar treatment of aqueous wastes.

4.3 Observations and Comments

The reliance on solar evaporation techniques for the disposal of toxic pesticide effluents in this location is both unreliable and unsatisfactory for reasons of:

- Existing effluent collection tank -
  Dimensions (width x length x depth = 5 x 10 x 1 metres) is too large and too deep for effective evaporation.

- Rates of evaporation in the wet season are insignificant.

- The residues after evaporation/concentration are of increased toxicity and continue to constitute an environmental safety disposal risk.

Toxic pesticide effluents should be collected, regularly treated, detoxified and disposed of using established treatment technology.

4.4 Effluent Treatment Proposals

4.4.1 Pesticide effluents arising from product formulation and packing activities can be fully treated and detoxified using a combined process of:

i. Chemical flocculation/clarification to coagulate and settle all suspended matter, including most of the pesticide in a small volume of manageable consolidated sludge.

ii. Adsorption of soluble organics including trace residual pesticides from the supernatant clarified effluent by controlled elution through columns of granular activated carbon.

4.4.2 Sludges from the process following filtration and air-drying amount to some 5 kgs of solids dry weight per cubic metre of effluent treated.

The alkaline nature of the sludge will initiate the partial degradation of entrained pesticide residues.

The sludges can be safely stored in polythene bags within steel drums to await controlled disposal as toxic wastes.

4.4.3 Exhausted carbons from the process similarly can be securely stored to await disposal. Pesticide residues bond strongly onto carbon, they do not readily leach off with water and normally require very high temperature for removal.

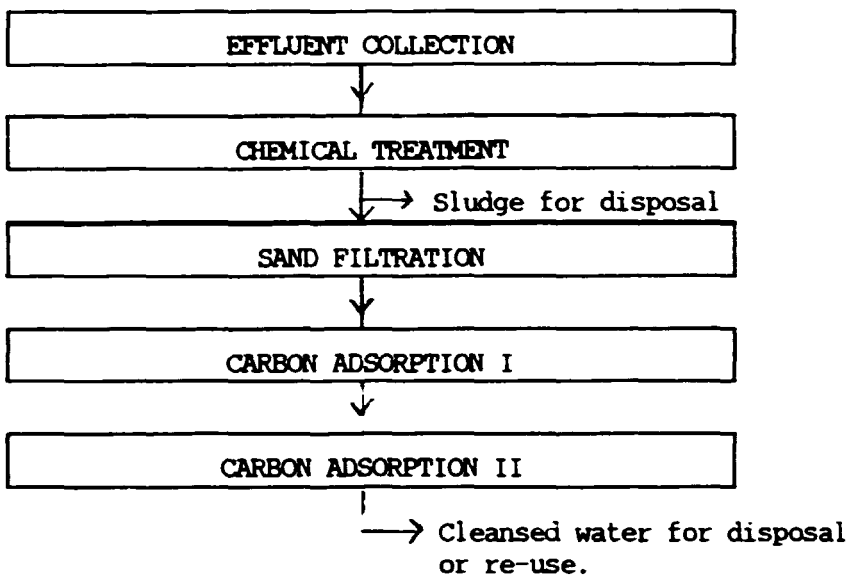
4.4.4 Final treated effluents are clear, colourless, odourless and non-toxic.

Examples of analytical data obtained on a range of pesticides treated by this type of process are given in Appendix III.

4.5. Effluent Treatment Plant

4.5.1 A complete package treatment plant is currently marketed under the trade name of "Sentinel/Carbo-Flo" (Ref. 1)

Designed specifically for the treatment of pesticide aqueous effluents, the process operates on a batch treatment principle, with the capacity of one cubic metre of effluent in the following stages:



Full details and specification for the "Sentinel/Carbo-Flo" treatment plant are listed in Appendix II.

4.5.2 Treatment chemicals/carbon adsorption modules.

These are provided in unit packs of four separate treatment chemicals. Each pack being sufficient to treat one cubic metre of effluent.

Replacement modules of carbon are provided in the form of 25 kg bolt-on units.

4.5.3 Sludge de-watering.

Bag-filter cloth assemblies for sludge de-watering prior to air-drying are provided.

A sludge coagulation conditioning agent is also provided along with dispensing equipment.

4.6. Effluent Quality - Monitoring Before Discharge/Disposal

Each batch of effluent treated should be analysed for compliance with a quality standard before disposal.

A typical list of test parameters and tentative maximum allowable concentrations is given in Table I.

Table I

TEST PARAMETER	TENTATIVE LIMITS - MAXIMUM ALLOWABLE CONCENTRATION (Note II) mg/L
Appearance	colourless - odourless
Ph	6 to 9
Chemical Oxygen Demand (COD)	< 50
Individual Pesticides	< 0.1
Total Pesticides	< 0.5
BOD - see Note I	
Note I Biological Oxygen Demand (BOD) is sometimes stipulated by controlling authorities as a mandatory requirement for treated effluent and must, in such instances, be included in the test schedule. It should be noted however that BOD is not a reliable quality parameter for pesticide effluents, as some of the components are not readily biodegradable.	
Note II In the event of legal standards for effluent discharge quality being imposed by a controlling authority, the most stringent standard shall apply.	

4.7 Records

Records of all effluents, batch, volume treated, analytical data and method of disposal must be completed and retained for future reference.

4.8 Recommendations

4.8.1 A central effluent treatment facility must be established within the site secure waste processing area (see also 5.5.2).

4.8.2 Effluent Collection

The existing effluent collection/evaporation tank should be modified with internal dividing walls to comprise:

2 x effluent collection vessels (connected by a common-drain to plant areas)
2 x final treated effluent storage vessels

This configuration will allow for adequate effluent storage even with future site expansion. Also flexibility of vessel rotation in the event of necessary cleaning and de-sludging without taking the process off-line.

Provision should be made to cover the vessel with rigid plastic sliding screens to exclude rain-water and removal during dry season for volume reduction by evaporation.

4.8.3 Laboratory Effluents

The laboratory effluent collection vessel should be retained and similarly modified but collected effluents transferred (initially) by tank to the main plant for treatment.

4.8.4 Effluent Treatment Plant

A Sentinel/Carbo-Flo MKII effluent treatment plant should be acquired to treat all site-aqueous effluent.

It should be sited within the factory waste-area (Appendix I) on a concrete pad with a load bearing capable of supporting at least 2 metric tonnes.

4.8.5 Effluent Treatment Chemicals and Adsorbents

Treatment chemicals and activated carbon are not readily available in Myanmar.

It is strongly recommended therefore that, pending the investigation for suitable sources of local supply, sufficient quantities of standard treatment chemicals and adsorbents are purchased with the treatment unit.

i.	Standard chemical unit packs (one per cubic metre of effluent treated)	30 packs
ii.	Activated carbon 25 kg modules	2 only
iii.	Sludge conditioning agent	5 litres
iv.	Sludge conditioning dispensing pump	1 only
v.	Sludge filter cloths	10 only

4.8.6 Treated Effluent Quality

Analytical resources with the analytical laboratory should be upgraded to accommodate the range of analytical parameters including residual pesticides listed in section 4.6.

4.8.7 Treated Effluent Disposal

Treated effluents from the Carbo-Flo process are non-toxic and should be regularly disposed of by irrigation onto grassland within the factory site

As a matter of policy no effluents should be discharged into surface water drains.

4.8.8 Sludge Disposal

De-watered, air-dried sludges from the process are potentially toxic and must be stored in strong plastic bags with a secure steel drum to await safe disposal.

5. WASTE DISPOSAL

With only partially developed formulation activities on-site, waste arisings overall are relatively low, but are potentially toxic and present problems for disposal.

5.1 Waste Types

Waste arisings can be classified into the following types:

i. Non-toxic - clean, paper, cardboard and plastic (mainly package materials)

ii. Lightly contaminated - spillage adsorbents, swabs, contaminated bags, drums and containers

iii. Toxic - un-wanted raw materials and finished products, solvent residues, laboratory waste, chemicals and solvents, effluent sludges.

5.2 Current Disposal Practises

Non-toxic wastes - segregated and sent to recycling outlets.

Lightly contaminated wastes - contaminated adsorbents (sawdust), paper bags, etc, about 25 kg per month.

Attempts at burning caused smoke and fume leading to external complaints from local residents. This practise has been discontinued and wastes are being accumulated in drums to await a more satisfactory disposal outlet.

Contaminated drums are triple-rinsed with solvent during transfer of contents to the batch process vessel. Washings are recycled.

Rinsed, non-toxic drums are sold for industrial use to the local soap industry.

Toxic drums - all of which have contained active pesticides are rinsed with alkali solution (washings to effluent system), de-headed, cut open and flattened into metal sheets. Currently a large quantity of sheets are stored awaiting prospective use elsewhere.

Toxic Wastes - currently, with the in-house policy of recycling at source and the frequent product turn-around, no significant stocks of toxic wastes have accumulated for disposal.

5.3 Waste Storage

All drummed and packaged wastes are currently held in the finished product store to await suitable disposal outlets.

5.4 Observations, Comments and Proposals

There are no organised disposal resources for industrial and toxic wastes in Myanmar at present (Ref. 2).

Landfill (refuse) dumps are open, accessible and scavenged by the public. During the wet season, many sites are flooded, making them unsafe and unsuitable for the disposal of industrial and toxic wastes.

The present alternative is to store wastes securely to await the emergence of suitable safe disposal outlets.

5.4.1 Recycling and Re-use

Every effort is made to recycle all wastes, where suitable, at source and reduce quantities for disposal to a minimum.

5.4.2 Drums

The disposal of clean, non-toxic drums (solvent and surfactant) for alternative use is good practise and commendable.

It is important to regularly clear these from the site to avoid accumulation. Large numbers of drums currently await disposal.

Drums and other containers which have contained active pesticides cannot be fully de-toxified and should not be re-used outside of the pesticide industry.

These must be de-contaminated, punctured or crushed to prevent re-use and subsequently disposed of to a steel smelter for metal reclamation.

The acquisition of a proprietary drum crusher would provide a rapid and effective method for processing and rendering drums unusable in a compacted state for scrap metal recovery (Ref. 3).

5.4.3 On-site Waste Handling, Treatment and Disposal - Future Initiatives

The disposal of all industrial wastes is becoming extremely environmentally sensitive and difficult. Future legislation will require the waste producer to fully identify, record, and securely package all wastes and ensure these are disposed of in a safe and responsible manner.

It is essential therefore that a system of waste management, operated by designated personnel is established on-site.

Secure areas for waste handling and storage in a separate

location are essential.

On-site initiatives for waste treatment and disposal should be explored.

The acquisition of a high temperature incinerator would prove a positive step to self-sufficiency in the disposal of virtually all waste types produced on-site. While toxic waste arisings are small, these will increase with the expansion of the factory site in the form of residual product wastes, effluent sludges and exhausted carbon, etc.

5.5 Recommendations

5.5.1 Waste Handling and Management

A system of waste collection, storage and disposal, operated by designated personnel should be established on-site.

The key elements of the system should include:

i. Colour-coded drums for waste deposition and collection should be provided in all work areas:

- green - non-toxic waste
- grey - lightly contaminated waste
- red - toxic waste.

These should be checked on a daily basis and where necessary cleared from the workplace.

ii. Waste Classification and Records

All wastes must be segregated into specific types, securely packed, clearly labelled and where appropriate hazard signs affixed. Records must be kept of all waste types, quantities involved and ultimate disposal outlet.

5.5.2 Waste Handling, Storage Area/Effluent Treatment Plant

A dedicated secure area should be established, away from manufacturing plant to process and store wastes to await disposal. It is recommended also that the effluent treatment plant be located in this area, sited in the southwest corner of the site (Appendix I).

Essential Features:

i. An area, about 25 x 25 metres dimension to accommodate both effluent, waste treatment, handling and storage activities.

ii. The area must be enclosed with a secure perimeter fence at least 2 metres high with double gates to permit vehicle access.

iii. Concrete roadways and hardstanding should be provided and where appropriate bunded to contain spillages.

iv. Essential plant and equipment within the secure area will include:

a) effluent treatment plant (essential acquisition),

b) drum crusher (essential acquisition),

v. A covered, well-ventilated, area for waste storage awaiting disposal,

vi. Small office space to prepare labels and records,

vii. Waste compost area.

5.5.3 Waste Disposal Initiatives - In-house

It is unlikely, in the short to medium term that any external waste disposal outlets for toxic pesticides will emerge. Serious consideration should be given to the following disposal initiatives for lightly contaminated and toxic wastes respectively.

i. Lightly contaminated wastes - alkaline compost treatment.

Low concentration pesticide wastes (adsorbents, sweepings, swabs, etc) are composted in admixture with soil and lime in controlled beds.

Alkaline conditions and bacterial action cause the gradual breakdown and detoxification of pesticide residues (Appendix IV).

ii. High Temperature Incineration.

The ideal objective for the site is to establish full in-house treatment and disposal facilities for all waste arisings.

The only complete effective solution for pesticide wastes is thermal destruction by high temperature incineration.

Serious consideration should be given to the acquisition of a package high temperature incinerator with adequate capacity to incinerate all site wastes including drums as sufficient quantities arise.

The essential elements for the thermal combustion of pesticide wastes are:

Primary combustion temperature 600 - 800 °C

Secondary combustion temperature 1200°C

Residence time 2 seconds

Capacity - liquid and solid wastes

Acceptance of drums up to 200L capacity

High stack - 20 metres.

Loading of unit : on an intermittent basis with generally light organic content waste - support fuel may be required.

Stack gases of combustion would be diluted on exit and dispersed.

The use of gas scrubbing equipment (which would increase overall costs threefold) is not at this stage justified.

Provision should be made to ensure that scrubbing equipment could, at a later date, be added to the incinerator if future quantities and composition of wastes deem this to be necessary.

Package incineration units with combustion capacity of up to 200 kg per hour with capability to accept drum wastes are available in Western Europe (Ref 4 and 5).

Location of Incinerator:

Owing to possible fire risk, it is proposed that the site for a waste incinerator should be located in the north west corner of the site away from production and storage areas (Appendix I).

5.5.4 Toxic Drum Disposal

All drums and containers which have contained active pesticides must be detoxified, punctured and preferably crushed. Final disposal should be to a steel smelter for scrap metal recovery.

6. INDUSTRIAL HYGIENE/SAFETY

Special Note:

A detailed safety audit of the site operations was carried out by Dr M.G. Srivastava, Consultant to UNIDO, during the same period 14-27 November 1991.

Acknowledging the overlap of some areas of hygiene and safety issues the following observations are made and comments and recommendations offered.

6.1 Workplace Environment

All current production is based upon the formulation of solvent-based pesticide emulsion concentrates (EC's) containing Cypermethrin, Diazinon, Endosulphan, Fenitrothion and Phenthoan. The main solvent used is Xylene.

6.1.1 Safety Supervision

At present all safety orientated responsibilities are vested in the project director. No provision has been made to delegate these responsibilities to a responsible person for workplace implementation on a day-to-day basis.

6.1.2 Plant Safety

The plant area is large, well ventilated via louvre windows and roof vents.

All solvent storage, formulation vessels, charging hoppers and filling cubicles are fully extracted via a large externally-sited scrubber unit containing alkaline sodium hypochlorite.

6.1.3 Finished Product Filling-Line

All liquid formulated product is filled via an automated filling line and dispensed into 500 ml glass bottles. The equipment is fully enclosed within an extracted cubicle connected to the vapour scrubber unit.

6.1.4 Warehouse - Xylene Storage

Large volumes of Xylene, packed in 200L drums are stacked end-on, four high in pyramid style within the store.

Palletisation is not used. Drums are physically man-handled from the stack onto the prongs of a fork lift as required.

6.1.5 Safety Equipment and Protective Clothing

All operatives are issued with personal safety equipment and protective clothing. The prescribed use of this

appeared to rest with the plant manager.

6.1.6 Blood Cholinesterase Monitoring Tests

All staff are blood-sampled at six-month intervals and checked for blood cholinesterase activity as an indicator for possible exposure to organo-phosphate (OP) compounds.

The tests are conducted at Yangon Hospital by qualified medical staff.

6.1.7 Housekeeping

This remains the responsibility of the plant manager to ensure all work areas are clean and tidy.

6.1.8 Hygiene Atmospheric Monitoring

Currently no facilities exist to monitor workplace atmospheres for fume vapours or dust.

6.2 Observations and Comments

6.2.1 Work-place Environment, Exposure Risks

Potential exposure risks to operators could arise from contact with toxic chemicals and the effects of organic fume and vapours. Little dust is generated from current formulation activities.

Whilst the plant is well-extracted and where necessary cubiclised, gross leakage and spillage from product filling lines constitutes both a contact and vapour risk to operators (see 6.2.3).

6.2.2 Safety Supervision

The absence of an officially-appointed safety/hygiene/environment officer with status to supervise and implement necessary control measures constitutes a major constraint to the enforcement of these controls within the workplace.

The appointment and training of a suitable person is both urgent and essential to the future operation and maintenance of safety/environment standards on-site.

6.2.3 Filling Line Operation

A number of faults in the operation of the product filling line gave cause for concern, with particular reference to both contact and vapour exposure risk to operators.

i. Premature withdrawal of filling nozzles from the bottles before completion of liquid discharge cycle.

This caused severe contamination to outsides of bottles, the conveyor belt (inside and outside of the cubicle) along with gross spillage onto the floor.

ii. Jerking action of filling conveyor belt caused further product-loss from filled bottles; frequently these toppled over with further loss of contents.

iii. Filled bottles emerging from the cubicle, externally contaminated with product, were packed without cleaning into sales cartons.

iv. Gross leakage of product (i, ii, and iii) onto floors and working surfaces outside the extracted cubicles presented a fume and contact risk to operators.

v. Standards of safety protection in the use of overalls, gloves, and eyeshields, was inconsistent and in some cases totally inadequate for handling toxic materials.

Maintenance operators worked inside filling cubicles without full glove and eye protection.

vi. Plant Housekeeping

Standards could be considerably improved with more regular clean-up of spillages. Removal of accumulated wastes and the avoidance of storing excessive quantities of raw materials, bottles and packaging materials in the main formulation area.

6.2.4 Hygiene Monitoring and Atmospheric Tests

The liquids formulation plant is designed to contain all solvent and toxic vapours. All workplace areas are well ventilated with good air circulation.

Only at times of plant malfunction, when product loss or leakage occurs, localised exposure risk to operators may result.

As a complementary measure to in-built plant safeguards, a static vapour monitor would at times of product spillage and subsequent clean-up provide a means to measure vapour concentrations within the workplace (Ref. 6). (See also 9.3.)

6.2.5 Blood Cholinesterase Tests

i. The exact benefits of conducting blood cholinesterase activity tests at six-monthly intervals is questionable.

Activity levels of both plasma and erythrocites can depress and restore within short periods of hours or

days. There is a risk therefore, of OP contact exposure occurring undetected under the present six-month test regime.

ii. Baseline Data

It is essential that all new employees are blood-sampled and tested on three consecutive occasions prior to any workplace contact with OP compounds.

These baseline cholinesterase activity results form the 'Baseline' against which all future test results will be measured and assessed.

On-site Analysis for Blood Cholinesterase Activity:

The provision of equipment to determine on-site blood cholinesterase activity offers a number of benefits:

i. More frequent analysis of blood samples from all staff.

ii. Immediate assay of fresh blood (currently several hours delay occurs between sampling and analysis).

iii. Facility to regularly check and monitor the recovery progress of operators who have exhibited evidence of cholinesterase activity depression.

Details of a simple method for the laboratory determination of cholinesterase activity in blood plasma and erythrocytes is given in Appendix V.

6.2.6 Warehouse - Xylene Storage

The storage of large quantities of xylene in drums within an un-contained (un-bunded) store must be recognised as a potential fire risk.

The current practise of manhandling drums of solvent from various stack heights is dangerous for reasons of:

i. Injury to operators falling from the stack of drums.

ii. Loss of control of 200 litre drums of Xylene.

iii. Risk of spillage and spread of highly inflammable solvent on impact of drum with the floor.

6.3. Recommendations

6.3.1 Safety/Environment Workplace Supervision/Controls

While the Project Director remains responsible for overall site safety/environmental controls, these duties should be delegated to a responsible manager or superviser for day to

day implementation.

It is essential that the designated person for these duties receives adequate training appropriate for the job.

This should include a visit to an established pesticide formulation factory where full safety and environmental controls are in place and operational.

6.3.2 Filling Line Operation

Thoroughly overhaul and adjust equipment to eliminate spillage, product loss and exposure risk to operators.

Contaminated bottles should be washed clean prior to packaging in sales cartons.

6.3.3 Protective Clothing

All filling line operators and process workings and maintenance staff must wear overalls, gloves and eye protection in process and filling areas.

6.3.4 Housekeeping

All working areas should be cleaned on a daily basis to remove spillage residues and accumulated wastes.

Unnecessary accumulation of raw materials and packed finished product must be avoided with the regular transfer of these materials to appropriate storage areas.

6.3.5 Hygiene - Atmospheric Monitoring Tests

The acquisition of a static vapour monitor should be considered to monitor workplace and laboratory atmospheres for vapour contamination (Ref. 5).

6.3.6 Blood Cholinesterase Tests

i. All new employees must receive three successive tests prior to any OP product exposure to establish baseline data.

ii. Consideration should be given to on-site testing for blood cholinesterase activity.

6.3.7 Warehouse - Xylene Storage

Drums of solvent should be stored on wooden pallets for safe, controlled movement and stacking by forklift.

The acquisition of a 'forklift' drum clamp for movement of single drums should be investigated.

7. OTHER SAFETY, HEALTH AND ENVIRONMENTAL-RELATED CONTROL ISSUES

The following areas were reviewed and discussed with line-management.

Observations and recommendations for improvements, where necessary, are included.

7.1 Fire Prevention and Control

The Site is currently vulnerable to fire-risk.

The delivery of a fire tender is awaited; water supplies available on-site are inadequate.

Existing small hand-held extinguishers would be ineffective except for small localised outbreaks of fire.

A number of urgent remedial measures were identified:

i. Provide a large water storage reservoir of at least 150 cubic metres capacity. It should be located centrally on the site. See Appendix I.

ii. Provide a lock-off gate valve in the main surface-water drain outfall pipe to prevent escape of contaminated fire waters into local water courses.

iii. Erect a dry bunded lagoon area in south west corner of the site to store contaminated fire waters for treatment. See Appendix I.

iv. Weed growth is rampant on-site and in dry conditions presents a fire risk.

All grass and scrubland should be regularly cut-back to minimise this area of risk.

7.2. Site Appearance

The factory site at Hmawbi occupies some 12.5 acres. It is only partly developed, large tracts of land are un-used, weed growth is rampant, unsightly and constitutes a fire risk.

Considerable improvements would result from a phased landscaping programme.

Areas benefitting from immediate improvement include:

i. Main-gate entrance.

ii. Road island area - main office block, borders of main roadways linking plants, warehouses and other buildings.

A well-maintained site does much for the environmental image in the eyes of staff and public alike.

7.3 Public Relations - Impact of Site Activities on Local external Environment

The factory site is remotely situated from domestic residential areas, hospitals, or schools. An asbestos cement factory is located about one mile to the north of the Hmawbi plant.

A local committee of 8 residents from the neighbourhood act as a liaison group over local concerns.

To date, only one complaint has been recorded, concerning odours arising from burning contaminated sawdust. This practise has ceased.

7.4 Road Access

The state of the (public) earth road particularly in the wet seasons continues to give cause for concern.

The stretch between Tatkyigon and the factory site is at times virtually impassable.

The risk of vehicles shedding a load of chemicals en-route to or from the factory poses a real hazard to the local environment.

Pressures must be exerted on the controlling authorities to provide the road with a permanent hard surface.

8. PRODUCTION - QUALITY CONTROL

Following discussions with laboratory management it was ascertained that:

i. All raw materials and finished products were analysed to approved specifications.

ii. Batch samples and raw materials are stored for a period of 2 years.

iii. A batch numbering system has been introduced and is recorded on each sample.

iv. Each retained sample is 500 ml capacity (raw material sample volumes could be reduced to 250 ml).

v. Out-dated samples will be recycled in the appropriate production processes.

8.1 Analytical Laboratory

In addition to the normal range of standard laboratory equipment, a gas liquid chromatograph (GLC) with F.I.D. and E.C. detectors is also installed. A high pressure liquid chromatograph (HPLC) will also be added to the range in the near future.

This will increase the overall analytical scope for both production and environmental applications.

8.1.1 Specific methods of analysis will be required for the detection of residual concentrations of pesticides in effluents, water and air.

8.1.2 Hygiene/Safety Note

It was advised that HPLC techniques require large volumes of organic solvent during operation. Measures must be taken to ensure the HPLC instrument is located in a well-ventilated or extracted area to remove solvent vapours.

The acquisition of static vapour monitoring equipment will enable checks to be applied to the workplace atmosphere on a regular basis.

9. TRAINING, ENVIRONMENTAL AND OCCUPATIONAL HYGIENE

Three separate training sessions were given to site management and supervisers covering the following topics. Use was made of visual aids and hand-outs where practicable.

9.1 Effluent Treatment

Basic elements of:

- minimisation
- collection and storage
- chemical treatment
- carbon adsorption
- quality of final effluent
- disposal options.

9.2 Waste Disposal

- minimisation, recycling and re-use
- handling and storage
- labelling and records
- review of overall disposal options
- cost implications.

9.3 Industrial Occupational Hygiene and Safety

- operator protection: examples of protective clothing, breathing and protection equipment
- plant requirements for capture and removal of airborne dusts and vapours
- cleaning equipment and adsorbents
- methods and equipment for monitoring atmospheric dusts and vapours
- interpretation and use of monitoring data for workplace improvements.

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Mr B Buchanan	Chief Technical Adviser, Yangon Regional Development Project
U Hla Min	Programme Officer
U Tin Htut	General Services Manager
Ms Daw Khin San Aye	Finance

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U Ban Yi	Director Planning Pesticide Formulation Project MPI
U Win Kyi	Project
U Myint Swe	Project Manager
U Nan Tun Kyaw	Planning Engineer
U Saw Win	Production Manager
U Saw Mooler	Laboratory Manager
U Nyo Lay	Maintenance Engineer
U Mon Tin Win	Deputy Laboratory Manager

Myanmar Agricultural Services:

U Maung Maung Tin	General Manager

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REFERENCES

1. E Allman and Company Ltd
(Manufacturer of Sentinel/Carbo-Flo effluent treatment plant)
Birdham Road, Chichester, West Sussex, PO20 7BT, United Kingdom

2. Waste Disposal - discussions between K S Johnson (UNIDO) and Mr B Buchanan, Chief Technical Adviser, Yangon City and Regional Development Project, UNDP, Myanmar, 27 November 1991.

3. Rodan Engineering Co Ltd (drum crusher equipment)
Unit 5, Millbrook Business Park, Crowborough, East Sussex, TN6 3JZ, United Kingdom.

4. Disposal of Unwanted Pesticide Stocks
Guidance on the selection of disposal options - GIFAP, Avenue Albert, Lancaster, 79A. 1180

5. Michaelis Industrieofenbau (Incineration plant)
Postfach 130622, D 4000 Dusseldorf 13, Germany

6. Neotronics Ltd (Atmospheric monitoring equipment)
Parsonage Road, Takeley, Bishop's Stortford, Herts, CM22 6PU, United Kingdom

APPENDICES

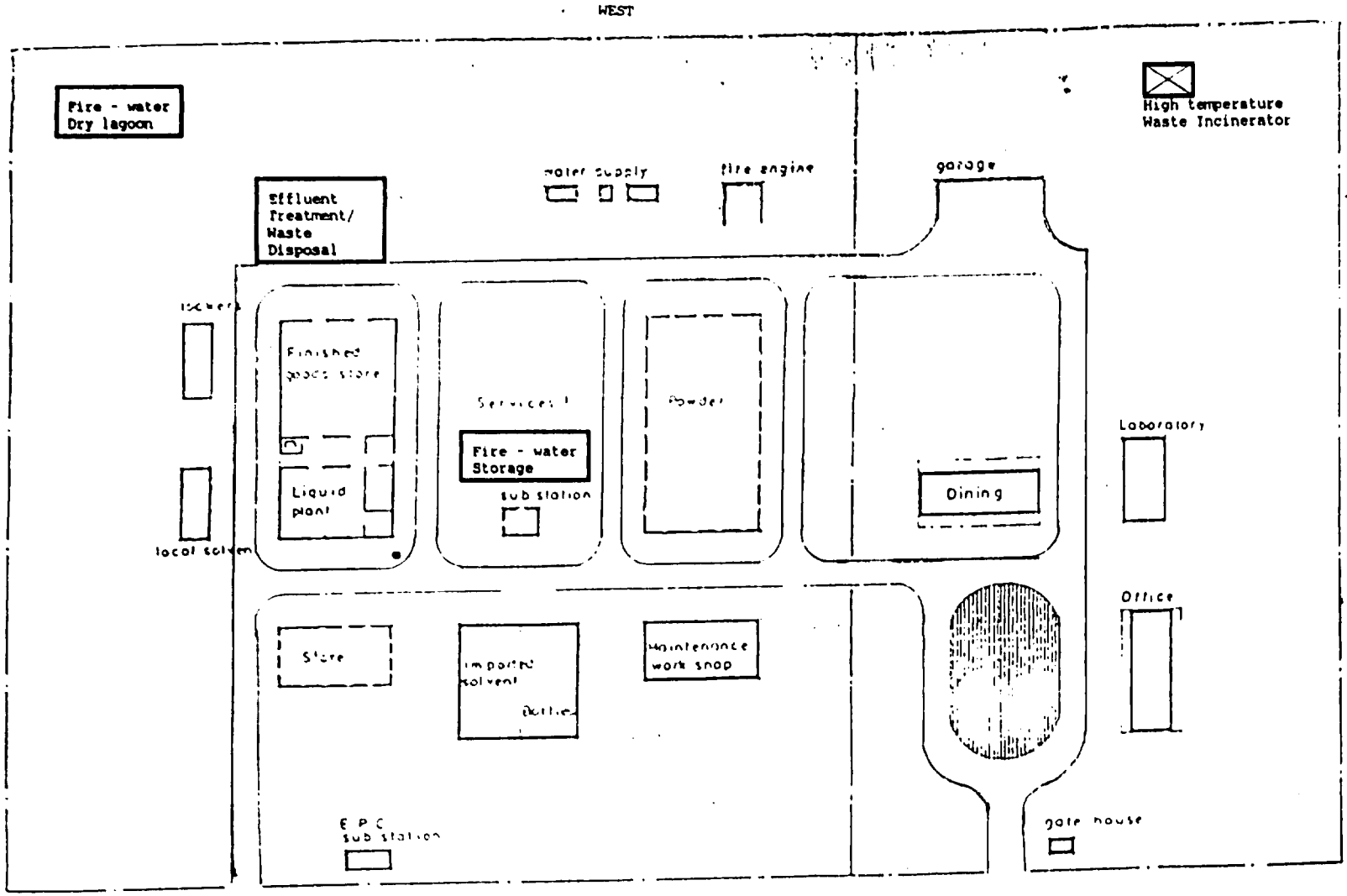
1. Site Plan - effluent, waste treatment, incineration, fire water lagoon, storage lagoon, location proposals.

2. Sentinel Effluent Plant Specification.

3. 'Carbo-Flo' Effluent Treatment Quality Analytical Data.

4. Waste Compost Treatment.

5. Determination of blood cholinesterase activity. Methodology.



B

PESTICIDES FORMULATION PLANT (Hmawbi)

Lay-out plan.

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ARCHITECT GROUP 2 CONSTRUCTION CORPORATION

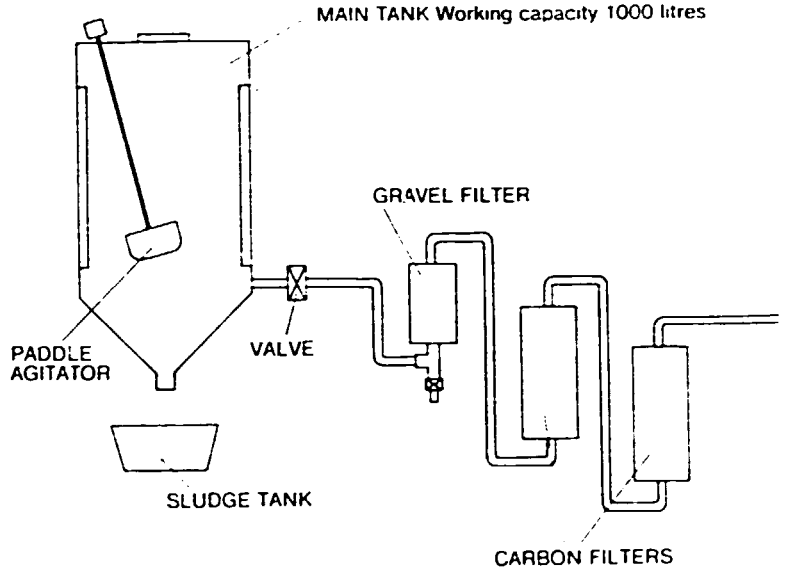
APPENDIX I

SENTINEL

APPENDIX II

ALLMAN in conjunction with ICI have developed the SENTINEL WATER EFFLUENT TREATMENT PLANT for use in small scale industrial operations as well as agriculture and other areas where environmental considerations are important. (The Carbo-Flo Treatment from ICI removes organic substances from the water.)

- A major step forward in the prevention of environmental pollution.
- Treatment packs designed for each 1000 litre batch of effluent.
- A tried and tested system used by ICI in large scale industrial operations worldwide.
- Treatment 'cleanses' contaminated liquors to give water which can be safely discharged into soakaways and sewers, providing water authority consent has been granted. The small quantities of sludge produced can be disposed of to land-fill via waste disposal contractors.
- Tell-tale colour indicator for filter saturation.
- Portable or fixed plant available.



SPECIFICATION

COLLECTION TANK	1000 litre working capacity. Manufactured from polyethylene, rotational moulded with sludge transfer valve. Overflow safety cut-out to prevent accidental overfill.
AGITATION PADDLE	Electrically driven motor, 12 volt DC / 240 volt AC single phase. Mechanical action.
FILTERS	One gravel pre-filter with back flow cleaning facility. Two activated carbon filters with replaceable elements.
FILLING PUMP	Centrifugal pump driven by 2 hp single phase electric or 3 hp petrol engine.
SLUDGE COLLECTION VESSEL	Manufactured from polyethylene c/w sludge drain device.
FRAME	Constructed from mild steel, c/w access ladder and guard rail, facility for three point linkage and/or fork lift.
LIQUID CIRCUIT	5 metres of suction hose c/w floating filter, and all necessary valves and discharge pipes.
SHIPPING WEIGHT	680 kg
DIMENSIONS	2.2 x 1.16 x 3.0 m
OPTIONS	Active agent infusion system. Castor wheels. Remote electronic control. Operator protective kit. Spray boom collection kit. Clean water tank.

Sentinel is designed for use with *dilute* solutions of organic chemicals. Follow the directions in the instruction manual.

Tests have been carried out under controlled conditions under which known concentrations of organic chemicals have been processed and the treated water subjected to laboratory analyses.

Tables 1, 2 &3 below set out results from the limited range of pesticides so far tested.

Table 1. Holland 1988 *Wageningen Institute**

Product or Range of Products	Effluent Initial Loading µg/l (ppb)	Residue in Treated Water µg/l (ppb)	Reduction %	Limit of Detection µg/l (ppb)
Atrazine	240,000	N.D.	>99.9	0.06
Bentazon	480,000	N.D.	>99.9	0.075
Organo-N	<2 to <25	N.D.	—	0.1
Organo-P	<0.1 to 88	N.D.	—	0.05
Organo-Cl	<0.1 to 100	N.D.	—	0.01

In biological tests, treatment resulted in a reduction in toxicity of between 20 and 2000 times for Daphnia and Algae respectively. By pH adjustment a further reduction in toxicity of 4 times was achieved.

*Translated from the Dutch
WAGEMAKER FH 1989. Orienterend onderzoek naar de effektiviteit van een kompakte fysisch-chemische zuiveringsunit voor afvalwater verontreinigd met bestrijdingsmiddelen. Rapportage van de werkgroep 'CARBO-FLO'. Ref 89-064X

Table 2. USA 1989 *Ohio State University**

Product	Effluent Initial Loading µg/l (ppb)	Residue in Treated Water µg/l (ppb)	Reduction %	Limit of Detection µg/l (ppb)
Atrazine	5,100,000	4.0	>99.9	0.4
Alachlor	795,000	<4.8	>99.9	0.4
Permethrin	237,500	N.D.	>99.9	0.4
Atrazine Tank	92,400	4.0	>99.9	0.4
Alachlor Mix	510,000	N.D.	>99.9	0.4
Permethrin	1,052,000	N.D.	>99.9	0.4

*Unpublished Report Available

Table 3. United Kingdom 1990 *Wessex Region NRA – Pewsham, Wilts.*

Product Tank Mix	Effluent Initial Loading µg/l (ppb)	Residue in Treated Water	Reduction %	Limit of Detection µg/l (ppb)
24-D	200,000	N.D.	>99.9	Between 0.02 and 0.04
Dicamba	35,000	N.D.		
Carbaryl	225,000	N.D.		
Pirimicarb	225,000	N.D.		
Cypermethrin	50,000	N.D.		
Paraquat	200,000	N.D.		

APPENDIX IV

ON-SITE TREATMENT OF LIGHTLY CONTAMINATED PESTICIDE WASTES USING PROCESS OF ALKALINE COMPOSTING

1. Significant quantities of lightly contaminated wastes including spillage adsorbents (sawdust), paper towels, swabs, and sweepings, regularly arise for disposal.

   Whilst low in pesticide concentration the wastes are potentially toxic and must be disposed of safely without harm to the environment.

   The waste cannot be buried because of groundwater contamination risk, or burned because of emission of toxic fume and smoke.

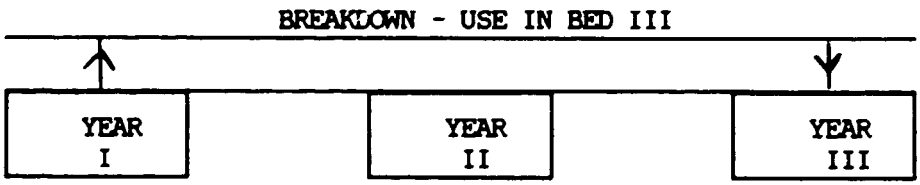
2. Alkaline Compost Disposal Method

   Low concentration pesticide residues for the most part degrade and breakdown under alkaline conditions.

   The alkaline compost method consists of intermixing residual pesticide wastes with alternate layers of soil and lime under controlled conditions.

   The process - consisting of a raised compost bed is stored untouched for a period of two years. During this period the combination of alkaline conditions along with bacterial activity causes the breakdown and decomposition of pesticide residues.

   The compost beds are normally operated in rotation over 2 year periods. At the end of the 2 year period, the original bed (No. 1) can be broken down and used to prepare subsequent beds using the same process.



Compost Bed Details

Bed Size: About 3 x 2 metres
Depth: About 1 metre
Build up layers to about 1.5 metres.
Cap off with 10 cm soil cover with plastic sheet.

Soil/lime waste layers approx 10 cms thick

PESTICIDE RESIDUES
LIME
SOIL
PESTICIDE RESIDUES
LIME
SOIL
IMPERVIOUS CLAY OR PLASTIC SHEET AT BASE ON GROUND LEVEL.

ENVIRONMENTAL & HEALTH MONITORING METHOD

THE DETERMINATION OF BLOOD PLASMA CHOLINESTERASE ACTIVITY

Outline of Method

Certain organophosphorus and carbamate pesticides may act as cholinesterase inhibitors if absorbed by the body, thus endangering the health of persons working with them. Before any possible exposure to these compounds personnel should have their normal cholinesterase activity determined at least three times. Thereafter determinations should be done to monitor individuals at risk for any depression of cholinesterase activity, indicative of contamination by this type of pesticide, and also to ensure continuity of safe working conditions.

A small blood sample is centrifuged to separate the plasma from erythrocytes. The cholinesterase activity is determined by measuring the decrease in pH of an acetylcholine solution due to the liberation of acetic acid when mixed with the plasma sample; it is expressed arbitrarily as 100 times the rate of fall of pH per hour.

Reference

Wolfsie, J.H., and Winter, G.D., Arch. Industr. Hyg., 1952, 6, 43.

Apparatus

Normal laboratory equipment is assumed to be available, only costly or unusual items are described.

pH Meter, capable of accurately measuring to 0.01 pH unit, preferably with a digital display. Fitted with a combined glass and reference electrode which will fit into the test tubes used for the determination.

Centrifuge and tubes, a haematocrit centrifuge with a rotor for 0.4 ml heparinised plastic tubes. Centrifuge and tubes are available from Gelman Sciences Ltd., Northampton.

Waterbath, to maintain temperature at 25°C, fitted with a rack to hold the test tubes. A suitable bath and rack is available from Grant Instruments (Cambridge) Ltd.

Test tubes, disposable plastic tubes 100 x 15 mm. A suitable tube, type 55.466, is available from Sarstedt Ltd., Leicester.

Lancets, sterile disposable lancets may be obtained from BCL, Lewes.

Natelson capillary tubes, heparinised, 0.20 ml, available from BCL, Lewes.

Blood pipettes, 0.02 ml, available from American Hospital Supplies Ltd., Didcot.

Stopclock

Dispensing micropipette and disposable tips to deliver 0.20 ml, available from BCL, Lewes.

Chemicals

Normal laboratory reagents are assumed to be available, only less common chemicals are described. All chemicals should be of Analytical Reagent grade.

Acetylcholine chloride, this material is hygroscopic and should be brought in small bottles which must be kept tightly closed and not allowed to stand open to the atmosphere.

Acetylcholine solution, dissolve 0.30 g of acetylcholine chloride in 10.0 ml of water. Prepare this solution fresh each day.

Buffer solution, dissolve 1.237 g of sodium barbitone, 0.136 g of potassium dihydrogen phosphate and 17.54 g of sodium chloride in about 900 ml of water. Add 11.6 ml of 0.1N hydrochloric acid with thorough mixing, then adjust the volume to 1 litre. The pH should be 8.00 at 25°C. Add a few drops of toluene as a preservative and store at about 0°C; do not allow the buffer to freeze.

Procedure

WARNING. Blood samples and blood contaminated equipment present a biological hazard. Surgical gloves must be worn throughout the procedure and all contaminated equipment, gloves included, must be disposed of so as not to cause a hazard to others. Incineration is the recommended means of disposal.

1. Blood sampling. This should normally be done by medical staff, details of the procedure are included for guidance when medical staff are not regularly in attendance.

1.1 Cleanse the lobe of the donor's ear with a small piece of gauze soaked in surgical spirit, then wipe it dry with sterile gauze.

1.2 Remove a sterile lancet from its wrapping, ensuring that the blade it not touched. Grip the lobe of the ear with the finger and thumb of the free hand and positively pierce the cleansed area with the point of the lancet.

1.3 Immediately discard the lancet - it must not be used again - and collect the blood sample in a Natelson capillary tube through the tapered end until the tube is three quarters full. It may be necessary to manipulate the lobe of the ear between the finger and thumb to ensure a steady flow of blood, this is done by alternatively squeezing and releasing the lobe during the filling of the capillary.

1.4 Touch the tapered end of the capillary tube on the inside of a plastic centrifuge tube so that the blood flows into the centrifuge tube, cap the tube and label it with the donor's name.

1.5 Centrifuge the sample for 2 minutes. It should separate into plasma, a clear upper layer, with the red erythrocytes at the bottom, if there is evidence of erythrocytes still suspended in the plasma increase the centrifuging time until they are removed.

1.6 The cholinesterase activity should be determined as soon as possible after sampling, if this is not possible the samples may be kept for up to 24 hours in a refridgerator at 5°C.

2. Determination of Cholinesterase Activity

2.1 Put sufficient test tubes for two determinations per sample into the rack in the 25°C waterbath. Add 1.0 ml of water to each one and allow to stand for 15 minutes.

2.2 Draw 0.02 ml of the plasma into a blood pipette taking care not to draw up any erythrocytes and disperse in 1.0 ml of water in one of the test tubes. Rinse the pipette with the solution. Using a new blood pipette treat a duplicate in the same way.

2.3 Add 1.0 ml of buffer solution to each tube, mix and replace in the 25°C waterbath.

2.4 Standardise the pH meter to pH 7.0.

2.5 Without removing the plasma sample from the waterbath add 0.20 ml of acetylcholine solution by means of a dispensing pipette, mix thoroughly with the pH electrode, record the pH and start the stopclock. Repeat this procedure with each sample at 30 second intervals.

2.6 Exactly 1 hour after the addition of the acetylcholine solution to the first sample mix briefly with the electrode and record the pH again. At 30 second intervals as each hour is completed treat the appropriate sample in the same way.

2.7 Calculate and record the cholinesterase activities of the samples:-

$$= 100\ (pH_0 - pH_1 - b)f$$

where pH_0 = initial pH reading
pH_1 = pH reading after one hour
b = correction for non-enzymatic hydrolysis
f = correction for variations in pH per hour with pH.

Values of b and f appropriate to the final pH reading pH_1 are given in the following table:-

pH_1	Corrections for cholinesterase activity in plasma	
	b	f
7.9	0.09	0.98
7.8	0.07	1.00
7.7	0.06	1.01
7.6	0.05	1.02
7.5	0.04	1.02
7.4	0.03	1.01
7.3	0.02	1.01
7.2	0.02	1.00
7.1	0.02	1.00
7.0	0.01	1.00
6.8	0.01	1.00
6.6	0.01	1.01
6.4	0.01	1.02
6.2	0.01	1.04
6.0	0.01	1.09

UNIDO Substantive Comments

The report gives an extensive survey of the operation of the pesticide formulation plant at Hmawbi. The expert who has worked in many pesticide formulation plants worldwide, has given a thorough survey with respect to occupational and environmental safety of the plant. He has itemized various recommendations and actions to be taken to bring the plant to international standards. The very fact that the plant is located away from the townships gives the added advantage of not interfering with urban population during its routine operation. On the other hand the standard of the approach road to the plant needs very much to be desired and unless action is taken by the Government to surface the road, it would lead to accidents during transport of finished products.

UNIDO has already taken action recommended by the experts but need additional measures to be taken by the project authorities to control the waste management in the plant.

Landscaping of the site is an important job to be carried out by the project authorities and in addition, they should appoint a safety officer. It is necessary to go through the observations of the experts item by item and take action as needed. UNIDO experts will be able to assist to carry out the necessary work in association with the MPI.

The report amounts to a safety audit with respect to occupational and environmental safety and it is essential that the expert's return mission is planned appropriately to monitor actions taken and also to assist in carrying out some of the recommendations.