

PROCEEDINGS
OF THE
REGION VIII
PESTICIDES DISPOSAL CONFERENCE
U.S. ENVIRONMENTAL PROTECTION AGENCY
DENVER, COLORADO
APRIL 4, 5, and 6, 1973

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PREFACE

The accumulation of unwanted pesticides and used pesticide containers is becoming an increasingly pressing nationwide problem. Due to the difficulties of collecting materials distributed over wide areas, the states in Region VIII do not yet have coordinated programs to deal specifically with these wastes -- most of which are not suited to disposal in municipal sanitary landfills.

Under Section 19 of the Federal Insecticide, Fungicide, and Rodenticide Act, procedures and regulations for the storage and disposal of unwanted pesticides are in process. The Region VIII Pesticide Disposal Conference and Workshop was conducted so that we can begin laying the groundwork to handle these problems before they present additional hazards to the public and the environment through inadequate or uncontrolled disposal techniques.

These proceedings, including the workshop recommendations, are a first attempt at setting up guidelines for the different phases of the disposal process from which we can build workable solutions to these collection and disposal problems.

WORK GROUP RECOMMENDATIONS

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June 20, 1973

E P A DISPOSAL CONFERENCE

Transportation & Collection Section

The collection and transportation of various toxic materials can not be discussed in full without also discussing disposal and other areas of concern.

The subject of disposal has been studied and discussed for several years by hundreds of individuals and numerous committees and subgroups with little headway as yet having been made.

The following summary is hereby being submitted with the above facts in mind - and deals primarily with initial collection and transportation.

Within urban areas, there is little likelihood of a successful collection program. The nature of the urban pesticide problem differs greatly from the agricultural environment. The difference is principally in the quantity of pesticides needing disposal - and the types, with the much less toxic products being found in the urban area. Therefore, primary emphasis should be placed in the area of most need. Still, the program should involve the urban areas.

I. Primary source of chemicals.

- a. Pesticide Applicators
- b. Manufacturers
- c. Distributors, (Retailers, Wholesalers, Formulators, etc.)
- d. Body Politic
- e. Agricultural Units
- f. Home owners

The collection and transportation of toxic waste would involve several departments - both State and Federal - within a given area. The Committee feels that all agencies concerned should be represented on an advisory committee to discuss this topic prior to implementation since the program would not succeed without the consent and participation of all agencies concerned. This committee should be kept small so as to be workable, which is somewhat of a problem.

The following agencies are considered important to this advisory committee.

II. Advisory Committee

- a. Dept. of Agriculture
- b. Water Resources

EPA Disposal Conference (continued)

- c. Health Department
- d. Applicator Advisory Committee
- e. State Transportation Agency
- f. Extension Service
- g. Dept. of Interior
- h. Dept. of Defense (National Guard - Military)
- i. Colo. Agri. Chem. Assn.
- j. EPA

III. Collection Scope

a. Primary collection (Colorado as example)

1. Primary site (possibility of two)

The two sites felt most capable of handling and storage indefinitely are the Pueblo Army Depot and Lowry Bombing Range.

2. Secondary collection site

(1) Initial collection site

Approximately four secondary/initial sites on the Western Slope and three sites on the Eastern Slope.

Western Slope sites could be located on BLM property while the three sites on the Eastern Slope could be located at several points on State property.

Secondary sites would be open four to six weeks during the year with each collection period lasting two weeks. During the year, collections will be made at the Secondary site and moved to the Primary site.

Certain circumstances will call for initial deposit to be made at the Primary site.

These Secondary sites are for deposit by the principal problem groups - such as pesticide applicators, manufacturers, government agencies and chemical distributors. Until materials are deposited at collection site, they remain the responsibility of the individual or organization. Transportation to the site is the responsibility of the individual. Transportation from Secondary to Primary site will be under the control of the responsible designated agency.

Possible transportation arranged through Highway Department, Dept. of Interior or National Guard.

Personnel to aid in collection and transportation will consist of representatives from the Extension Service, Industry, Department of Health, Dept. of Interior and the Agriculture Department. Personnel from these agencies will aid in all phases of work, from manning collection sites and transportation to supervision.

b. Home owner collection

1. Five-week collection period.

2. Collection site established by County Agent (guidelines established through Advisory Committee.

3. Possible collection sites.

(1) Fire Stations (knowledge - but lack of space)

(2) Highway Dept. (space - but lack of knowledge)

(3) National Guard (space - some knowledge)

(4) Weed & Insect Abatement District)

4. Products removed to Secondary or Primary storage area.

Because of the types of products most generally abandoned by home owners, it is felt that 55-gallon drums should be placed at

EPA Disposal Conference (continued)

each county collection site for the purpose of collecting home owner products. It should be noted that several home owner sites may exist within a given county or metropolitan area. Transportation to the Secondary or Primary site will be accomplished in the manner previously mentioned.

A log will be kept on what has been collected and stored with entries beginning at the county level. The site will be monitored continuously and will meet specifications as outlined by the study group. Evaluation of the project will be made after the first year to see what, if any, projects should be carried out in the future, or to make improvements in the present system.

Empty container disposal is considered a large enough problem to warrant special consideration. Amounts are such that a rinse/crush should be considered in each county as is needed, in cooperation with State and Federal agencies. This special consideration is needed because of problems in storage, transportation and economics. If reconditioning plants are available and meet various safety standards, then this disposal method would be satisfactory. It is recommended that EPA spearhead the development of a suitable mobile rinse/crusher for empty drums, with the equipment being made available nationwide upon demand.

DMB:jbf

PESTICIDE CONTAINER DISPOSAL CONFERENCE

April 4-6, 1973

Denver, Colorado

Prepared by: Dean K. McBride
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DISPOSAL FACILITIES

A. Location

- 1.) Soil characteristics
 - a.) check with SCS people for information on soil type in an intended disposal area.
 - b.) soil should be of a relatively non-porous nature.
 - c.) check with University soils department for information on soil types in an intended disposal area.
- 2.) Proximity to surface water and operating supply wells.
 - a.) check on 100 year flood schedule
 - b.) topography and drainage of the area.
- 3.) Nature of water table and its fluctuation over a period of years.
- 4.) Landfill site where a specific pesticide disposal area is designated.
- 5.) Proximity to human habitation, livestock etc.
- 6.) Zoned strictly as a pesticide disposal and/or storage area (consider future wells etc.).

B. On-Site Storage

- 1.) Pesticide container stack bays as according to procedure used by Oregon.
- 2.) Fencing, posting, monitoring.
 - a.) adequate fencing angled outward at the top 6 feet high.
 - b.) posting signs should be all-weather.
 - c.) signs should be in bright red and easily visible from all four directions.
 - d.) signs should be in English, Spanish and other languages where applicable.
 - e.) storage areas should be monitored at least twice a year.
- 3.) In situations where the distance to a landfill site having a pesticide container disposal facility is 35-40 miles radius or greater it is suggested that a pesticide container storage facility be built to accomodate farmers and commercial applicators within this 35-40 mile distance.
- 4.) Pesticides containers should be sorted to type of pesticide.

C. Site Design and Equipment *

- 1.) Dates and times specified for manned landfill disposal sites as well as storage sites possibly on a twice monthly basis (contact with county agent or other responsible person.)
- 2.) Adequate equipment available at landfill sites where pesticides and pesticide container disposal will be done.
- 3.) Pesticide disposal area should be well separated from disposal areas used by public.
- 4.) Diversion of surface drainage away from disposal area.
- 5.) Adequate posting of direction signs to pesticide burial site.
- 6.) Safety and safety equipment - protective clothing, goggles, respirators, gloves, soap, water.
 - a.) A qualified site foreman should be on hand at all times when pesticides are being disposed of.
- 7.) Depth of soil - at least two feet of compacted soil.
- 8.) Records of types and amounts of pesticides and where they are buried.

* Reference is made to feasibility study - Interim Guidelines for Land Disposal of Excess Pesticides and Pesticide Containers. (by M.W. Van Dyke)

D. Recommendations

- 1.) Adequate publicity to inform the public of pesticide container disposal sites and/or pesticide container storage sites - should indicate when sites will be open to receive pesticides and pesticide containers.
- 2.) Future Needs - Research into the pesticide disposal problems peculiar to each state within Region VIII and attempt to arrive at workable solutions through research and demonstrations coordinated by EPA.

Examples-

 - a.) pesticide degradation programs for pesticide disposal.
 - b.) portable incinerator.
 - c.) guidelines should be flexible enough to be compatible with existing state laws and regulations.
 - d.) soil degradation studies on pesticides.

PESTICIDE CONTAINER DISPOSAL CONFERENCE
April 4-6, 1973
U.S. ENVIRONMENTAL PROTECTION AGENCY
DENVER, COLORADO

Prepared by: Ronald Disrud
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DISPOSAL PROCESS

1. Problem Definition - Lack of adequate information on proper disposal techniques.

Background information - Disposal of in open dumps either private or municipal - (Past & Present)

Types of Waste and How Disposed:

Cans - Dumps
Barrels - Dumps & Returned to Mfg.
Bottles - Dumps
Bags - Burned & Dumps
Unwanted Pesticides - Dumps, sewage systems, spreading on
land, collection and storage.
Other Hazardous Wastes - Same as above

Legal Constraints - Transportation across state lines, unrealistic laws, lack of responsibility for authority.

2. Alternative Solutions -

Feasible Alternatives

(a) Storage

- (1) Temporary
- (2) Security
- (3) Space
- (4) Monitoring

(b) Use:

- (1) Rid of Material
- (2) New Law Restricts Some Use
- (3) Residue

(c) Landfill Disposal

- (1) OK for Rinsed Containers
- (2) OK for Small Quantities
- (3) Large Quantities or Concentrations Pose Problems

(d) Return Containers to Mfg. or Distributor or Recycled

- (1) Contamination
- (2) Transportation
- (3) Leakage
- (4) Label problems
- (5) Collection Points

(e) Incinerating

- (1) Cost
- (2) Emissions
- (3) Disposal
- (4) Transportation

(f) Bio-degradation

- (1) Lack of Technical Knowledge
- (2) Land

3. Preferred Alternatives & Implementation

System Description - A multiple disposal system involving incineration and Bio-degradation should possibly be developed, preferably at the same location.

System Management & Coordination - Coordination of all Federal & State Agencies involved in the pesticide problem.

Funding Requirements - Considerable

Legal - Transportation
Ultimate Authority

DISPOSAL ALTERNATIVES
A KEY TO DISPOSAL OF WASTE
PESTICIDES

NOTE: Return excess and surplus pesticides to original company if they accept surplus and excess pesticides

1. a.) Industrial-----
b.) A Pesticide----- go to 2
2. a.) Approved and current Registration----- go to 3
b.) No approved and current Registration----- go to 4
3. a.) Pesticide contaminated, adulterated, or with no label----- go to 4
b.) Not contaminated, adulterated, or with a label----- use it for approved and a real control program
4. a.) Inorganic classification----- go to 5
b.) Organic classification----- go to 9
5. a.) Commercial reprocessor available----- sell or contribute
b.) No commercial reprocessor available----- go to 6
6. a.) Incinerator available----- Incinerate, recover ash for valuable elements or burial in appropriate sanitary landfill (Except for Mercury residue)--- go to 8.a.)
b.) No incineration----- go to 7

7. a.) Possibility for incineration in near future----- storage
b.) No possibility for incineration in near future----- go to 8
8. a.) No. 1, approved landfill available----- chemically de-
activate and/or
encapsulate in-
organics & dis-
pose. (Excep-
tion to encapsu-
lation may be Ca
or NaOH.)
b.) No. 1, approved landfill available----- storage until an
approved landfill
becomes available.
Or incinerator
becomes available
9. a.) A water solu. chemical----- go to 10
b.) Not a water solu. chemical----- go to 14
(DDT)
10. a.) Effective decontaminates available----- decontaminate
and dispose in
an approved pes-
ticide landfill.
b.) No effective decontaminate available----- go to 11
11. a.) Conduasive to photodecomposition (if highly toxic may----- photodecompose
not be a disirable
method because of human
or environment risk.)
b.) Cannot be photodecomposed----- go to 12
12. a.) Conduasive to microbial degradation----- Soil incorpora-
tion within top
6" with a highly
organic media and
not exceeding
1000#/A.

- b.) Not conducive to microbial degradation----- go to 13
13. a.) A suitable pesticide incinerator available----- Incinerate,
collect ash or
place in #1 land-
fill.
- b.) No suitable pesticide available, or dilute
formulation----- go to 14
14. a.) Insecticide formulation----- storage
- b.) Herbicide (insol. in H₂O)----- go to 15
15. a.) Conducive to photodecomposition----- photodecompose
- b.) Not conducive to photodecomposition----- go to 16
16. a.) Conducive to microbial degradation----- soil incorpora-
tion (see 12. a.)
- b.) Not conducive to microbial degradation----- land disposal
or storage.

Specifications

- landfill site
- soil incorporation
- photodecomposition

Work Group Recommendations on State Legislation, Regulations
and Guidelines Needed for Pesticide Waste and
Container Disposal

Legislative Proposal

That the State Department of Agriculture, in cooperation with the Department of Health, be given authority to regulate the safe disposal, storage, or destruction of pesticides, and used pesticide containers in such a manner that potential pesticide danger to human life, vegetation, crops, livestock, or any other portion of the environment is minimized and the regulating agency be granted authority to draft regulation and cooperate with other State or Federal agencies.

Problem definitions and regulations need to be addressed to the following areas:

- A. The prevention of further accumulations of emptied pesticide containers.
 - 1. Rinsed or decontaminated containers.
 - a. Possibility of increasing exposure to pesticide poisoning when rinsing large containers (30 and 55 gal.).
 - b. For reuse (non-food or domestic) or return to manufacturer.
 - c. Disposal at approved designated sites.
 - 2. Collection and disposal of empty or partially filled containers already in the hands of pesticide users.
 - a. Disposal at designated or approved landfill site.
 - 1. Regulations for specific types of containers (metal, glass, plastic, and paper).

2. Regulations for landfill operation (Type I, II, or III similar to California designations).
 - b. Disposal by incineration or other approved methods of disposal.
- B. Safe transportation to collection or disposal sites.
 1. Responsibility of owner.
 - a. Take or send container or pesticide to proper site.
 - b. Comply with rules or regulations.
 2. Responsibility of the carrier.
 - a. Transport according to state or local regulations.
- C. Designate adequate disposal site and/or approved method for the disposal of unwanted pesticides.

It was the consensus of the group that regulations be established to fit the problem areas to fit an individual State's needs. California's laws and regulations can be used as a guide.

This report is respectively submitted to other members of pesticide waste and container disposal workshops by the following persons participating in the State Legislation, Regulation, and Guideline Workgroup.

Gale, Alvin F., Chairman	Wyo. Ext.
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CONFERENCE AGENDA

AGENDA

REGION VIII PESTICIDES DISPOSAL CONFERENCE

HOSTED BY:

U.S. ENVIRONMENTAL PROTECTION AGENCY, DENVER, COLORADO

APRIL 4, 5, and 6, 1973

APRIL 4

BACKGROUND INFORMATION

<u>Time</u>	<u>Item</u>	<u>Speaker</u>
8:30	Introduction	David A. Wagoner
8:45	Present Legislation and Guidelines (Including Sec. 19 FIFRA)	Larry P. Gazda Ivan W. Dodson
9:15	COFFEE	
9:30	Sanitary Landfill Design for Hazardous Wastes	Merline W. Van Dyke
10:00	Presentation by States - 15 minutes a) Problems b) Legislation	
11:30	LUNCH	
1:00	Rockwell International Project on Hazardous Waste Disposal	Dr. Donald E. McKenzie
2:00	Microbial and Chemical Degradation	Dr. Eldon P. Savage
3:00	COFFEE	
3:15	California Collection, Transportation, and Disposal Systems	Dr. Robert M. Pratt
4:15	EPA Hazardous Waste Classification	Dan W. Bench

APRIL 5

WORK GROUP SESSIONS

<u>Time</u>	<u>Item</u>	<u>Speaker</u>
8:30	Transport Regulations, Inter, Intra/state	Orris Gram
9:00	Hazardous waste sources related to Pesticides	Robert W. Harding
9:30	COFFEE	
9:45	Disposal Facilities	Harry W. Trask
10:15	Air Force Pesticide Biodegradation Research	Capt. Alvin Young
11:30	LUNCH	
1:00	Balcom and Pueblo Chemical Drum Cleaning and Crushing	Dennis M. Burchett
1:20	Work Group Discussion	
4:00	ADJOURN	

APRIL 6

8:30	Work Group Recommendations and Discussion
11:30	LUNCH
1:00	OPEN

WORK GROUP DESIGNATIONS

1. Collection and Transportation
 - a) Used Pesticide Containers
 - b) Excess and cancelled pesticides
 - c) Regulations
 - d) Recommendations
2. Disposal Facilities
 - a) Location
 - b) On-site storage
 - c) Site design
 - d) Recommendations
3. Disposal Process
 - a) Reuse of containers returnable to manufacturer or bulk shipments with reuseable containers
 - b) Disposal of non-recyclable containers
 - c) Disposal of current backlog of unwanted pesticides
 - d) Recommendations
4. Disposal Alternatives
 - a) Photo decomposition
 - b) Incineration
 - c) Microbial degradation
 - d) Chemical degradation
 - e) Storage (until satisfactory disposal methods become available)
 - f) Land disposal
 - g) Recommendations

5. Suggested State Legislation, Regulations, and Guidelines

a) Recommendations

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MATERIALS PRESENTED

Preliminary --
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INTERIM REGION VIII
PESTICIDES LAND STORAGE AND DISPOSAL GUIDANCE
JANUARY 1974

This report has been reviewed by the U.S. Environmental Protection Agency and approved for distribution. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency.

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FOREWARD

Interim Guidelines for land storage and disposal of excess pesticides and pesticide containers were developed by the Division of Hazardous Materials Control, EPA, Region VIII and are intended to serve the needs in Region VIII until other or more refined disposal methods become functional. Adequate site investigation of soils, geology, bedrock, water tables, etc., must precede disposal site selection. This guidance may, where soils and hydrology are different, not be widely applicable in other parts of the country, so should not be construed as national EPA guidance.

Draft guidelines were reviewed at the pesticide disposal conference held April 4-6, 1973 in the EPA, Regional Office. Reviewal was also solicited from the Regional Air and Water Programs and the Office of Pesticide Programs and Solid Waste Management. All comments received were taken into consideration when preparing this document.

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I. Landfilling - General

Most excess pesticides and pesticide containers can be placed in individually designed sanitary landfills. However, not all sites used in Region VIII today can be used for pesticides unless these sites are specially designed and constructed for that purpose.

While it is possible to construct a sanitary landfill on nearly all topographies, some land formations are more difficult than others to use, therefore, soil reinforcement may be necessary for pesticide wastes. This makes each sanitary landfill distinctive. It would be impossible to standardize all techniques required at every potential disposal site. This discussion is intended to cover those features and procedures that are intrinsic to a good sanitary landfill operation for pesticide land storage and disposal.

These interim guidelines will not supersede the proposed guidelines for "Land Disposal of Solid Wastes" or the proposed guidelines for "Disposal and Storage of Pesticide Related Wastes" being developed under Section 209 of the Resource Recovery Act and Section 19 of the Federal Insecticide, Fungicide and Rodenticide Act of 1972.

The following criteria are essential for landfilling pesticide wastes:

- A. All cells should be designed and constructed for a particular stockpile of ingredients.
- B. All cells should be constructed, filled and covered as rapidly as possible to maintain the integrity of the structure.
- C. Wastes should be temporarily stored until there is a sufficient quantity to warrant the design and construction of a cell.
- D. A detailed site description and a plat of the completed landfill should be permanently recorded in the appropriate office of legal jurisdiction.

II. Landfilling - Specifications

A. Site Location Requirements

It is important that the structure:

- 1. Be readily accessible for construction, operation, and maintenance;
- 2. Conform to zoning and land use requirements and plans of the area;
- 3. Not be located in a known flood plain;
- 4. Not be in an area where the ground water table is high; and

5. Contain sufficient and suitable cover material.

B. Site Design

Site development plans should include a topographic map showing land use and zoning within one mile of the disposal site. The map should show all homes, buildings, wells, watercourses, dry runs, rock outcroppings, roads, and other pertinent data, i.e., USGS 7 1/2 minute quadrangle map. Additional site detail should show the location of all soil borings to a depth sufficient to allow evaluation of water quality protection, location of proposed buildings, area roads and fences, and detailed contours or cross sections of proposed structures.

A report accompanying the plans and specifications should document the following:

1. The volume and comprehensive description of the waste materials which may be accepted for disposal;
2. The types of hazardous waste materials which can be stored together;
3. The geology, hydrology, and soil testings;
4. The interpretation and classification of all materials encountered in the site area using the Unified Soil Classification System;
5. The method of soil placement and/or structural additives;
6. The schedule of periodic inspections;
7. The responsible agency for construction and maintenance; and

8. The method of control of off/on site, surface and subsurface drainage.

C. Structural Parameters

1. Soil characteristics of the disposal site should have:
 - a. Classifications of CL, CH or OH by the USCS or some combination thereof.
 - b. A fine grained texture (more than 50% passing the number 200 sieve size - U.S. standard) as determined by testing procedures of AASHO T88.
 - c. A Plasticity Index (PI) greater than 20 by ASTM Test D424 or AASHO T90.
 - d. A permeability less than 10^{-8} cm/sec or 0.2 feet per year, whichever is less.
2. For structural integrity, soil should be placed in six inch layers and compacted with a sheeps foot roller of more than 4,000 pounds per lineal foot, to a density of 95% of modified proctor at optimum moisture content (ASTM Test D1557 or AASHO T180). Cell bottoms and sides should be constructed in a continuous operation.
3. Depth requirements of compacted backfill surrounding the material will vary with wastes placed in the structure. Using the EPA, Office of Pesticide Programs' classification, the following should serve as a guide until more complete data is accumulated:

8. The method of control of off/on site, surface and subsurface drainage.

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3. Depth requirements of compacted backfill surrounding the material will vary with wastes placed in the structure. Using the EPA, Office of Pesticide Programs' classification, the following should serve as a guide until more complete data is accumulated:

Hazardous Waste Class	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>
(depth of fill necessary in feet)	5	5	4	2	2

4. Soil types mentioned above may not be available in all areas of the United States. Therefore, reinforcements may be used to upgrade the soil characteristics, i.e., soil, cement, asphaltic materials, concrete bentonitic clays, impervious membranes, etc. When reinforcements are used, the recommended compacted soil depths may be reduced significantly.
5. The Cell shall be capped with a minimum of 2 feet of compacted soil.

D. Moisture Content

The water content of the earthfill materials prior to and during compaction should be distributed uniformly throughout each layer of the material. The soil water content should allow maintenance of the modified proctor laboratory condition.

(This optimum water content is defined as that water content which results in a maximum dry unit weight of soil when subject to the modified proctor compaction test). The proctor compaction tests should be conducted by a qualified person using the appropriate ASTM designation D1557 or standard AASHTO T180 method.

The material should contain the proper moisture content in the borrow pit before excavation. Supplementary water, if required, should be added to the material by sprinkling on the earthfill and should be mixed uniformly throughout the layers.

E. Rollers

Tamping rollers should be used for compacting the earthfill. They should be furnished by the contractor and should meet the following requirements:

1. Roller drums - Each drum should have an outside diameter of not less than five feet and should not be less than four feet nor more than six feet in length. The space between adjacent drums, when on a level surface, should not be less than twelve inches nor more than fifteen inches. Each drum should be free to pivot about an axis parallel to the direction of travel and should be equipped with a suitable pressure-relief valve.
2. Tamping Feet - At least one tamping foot should be provided for each 100 square inches of drum surface. The space measured on the surface of the drum, between the centers of any two adjacent tamping feet, should not be less than nine inches. The distance between the tamping foot and the outside surface of the drum should not be less than nine inches. The cross-sectional area of each tamping foot should not be more than ten square inches at a plane normal to the axis of the shank six inches from the drum surface, and should not be less than seven square inches nor more than ten square inches at a plane normal to the axis of the shank eight inches from the drum surface.
3. Roller Weight - The weight of the roller when fully loaded should not be less than 4,000 pounds per foot of drum

length. If more than one roller is used on any one layer of fill, all should be the same type and with the same dimensions. During rolling, the contractor should keep the spaces between the tamping feet clear of materials which would impair tamping.

III. Landfilling - Construction

A. General

1. Access to the site should be controlled to keep unauthorized persons out.
2. Open burning of waste should be prohibited.
3. Design provisions should ensure that no pollution of surface or ground water results from the operation. Routine monitoring should be performed by qualified personnel.
4. Provisions should be made for on-site control of potential gas movement from the landfill.

B. Preparation of the Foundation

No material should be placed in any section of the earthfill portion of the storage site until the foundation for that section has been prepared and approved by a qualified person. Test pits and all other existing cavities found within the area covered by the earthfill and which extend below the established lines of excavation for the structural embankment should be filled with material and compacted as specified for the earthfill. The foundation should be prepared by leveling and rolling so that subsurface material of the foundation will be as compacted and well bonded with the

first layer of earthfill as for each subsequent layer of earth. All rock, shale, and other undesirable materials should be excavated from the foundation as indicated in the plans or directed by a qualified person. Surfaces should be protected from air slacking and freezing. Surfaces upon or against which the earthfill portions of the structural embankment are to be placed, should be cleaned of all loose and objectionable materials in an approved manner by hand or other effective means immediately prior to placing the first layer of earthfill.

C. Waste Placement and Covering

1. Placing

The distribution and gradation of materials throughout the earthfill should assure that the fill is free from lenses, pockets, streaks, or layers of materials differing substantially in texture or gradation from the surrounding materials.

Placing of materials should be subject to the approval of a qualified person who may designate the placing of individual loads. Impervious materials should be placed in the central portion of the earthfill so that the permeability will gradually increase toward the outside. Cobbles and rock fragments with a diameter greater than three inches should be removed from the structural material.

Structural material should be placed in horizontal layers not more than six inches thick and then compacted. If the surface of the foundation or the rolled surface of any layer of earthfill is too dry or smooth to bond properly with the next layer of material, it should be moistened and/or worked with harrow, scarifier, or other suitable equipment to a sufficient depth to provide a satisfactory bonding surface before the next layer of earthfill material is placed. If the rolled surface of any layer of earthfill is too wet for proper compaction with the next layer to be placed, it should be removed or dried until the water content is satisfactory for compaction before the next layer of earthfill is placed.

2. Landfilling

- a. All slopes at the working face should enable machinery to function properly and be 3:1.
- b. Groups of hazardous materials should be in separate partitioned areas.
- c. Liquid materials, in barrels or drums, should have an appropriate absorbent placed around the containers to retain the liquid if leakage occurs.
- d. After all materials, pesticides, etc., have been placed, covering operations should proceed immediately.
- e. After compacting the cover material, all exposed earth should be covered with topsoil and appropriate grass or shallow rooted shrubs planted.

- f. Surface slopes on areas with intermediate or final cover should be at least two percent to facilitate surface runoff.
- g. At least semiannually, each site should be inspected by a qualified person and a report presented to the appropriate regulatory agency. Deficiencies, along with recommended corrective action, should be reported.



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TECHNICAL BRIEF

**THE ATOMICS INTERNATIONAL
MOLTEN SALT COMBUSTION PROCESS
FOR THE DISPOSAL OF PESTICIDES**

April 1973

INTRODUCTION

The disposal of pesticides in a non-polluting manner is an increasingly important problem. Conventional incineration leads often to toxic gases, e. g. phosgene, and the ash residue is often toxic.

Atomics International Division of Rockwell International Corp. has developed a Molten Salt Combustion process which can be used to dispose of pesticides in a non-polluting manner. The process takes advantage of two facts demonstrated at Atomics International:

- (1) Molten salts, containing non-volatile alkali metal carbonates, are excellent absorbents for acidic gaseous pollutants.
- (2) Carbonaceous materials are rapidly consumed in carbonate melts containing a dissolved catalyst.

CONCEPT

The Molten Salt Combustion process uses a sodium carbonate melt containing a dissolved catalyst. One of the important functions of the sodium carbonate is to instantly neutralize any acidic gases such as HCl. The catalyst accelerates the combustion process in the salt*.

In the present concept, the pesticide and air are blown into the melt, at 1800°F, using a continuous feeder. Several reactions take place upon the addition of the pesticide. Combustion occurs with the formation of carbon dioxide, steam, and acidic gases. The acidic gases are instantly neutralized by the alkaline sodium carbonate. In the case of chlorinated pesticides, any HCl that is formed is immediately converted to sodium chloride. Any char

*To illustrate the accelerated combustion rate in this process, the combustion of charred bituminous coal in the molten salt has been found to be 50 to 100 times more rapid than in conventional boilers.

remaining in the salt melt is completely consumed by reaction with air and the dissolved catalyst. Since the salt will combust all carbonaceous material and destroy glass and metal, pesticide containers can also be disposed of in the salt.

The process may be operated on a continuous or a batch basis. Thus, either a side stream may be treated to remove ash and recycle salt or the complete salt charge may be treated for disposal. Disposal of the spent salt is effected by treating the dissolved salt with lime to yield insoluble calcium compounds, e.g., CaSO_4 , $\text{Ca}_3(\text{PO}_4)_2$, etc. Thus, the only soluble compound in the spent salt is sodium chloride. Since it contains no pesticide, it can be disposed of by burial or by dumping into the ocean.

TESTS WITH PESTICIDES

Laboratory bench scale tests have been carried out on four different classes of commercial pesticides. These were: chlordane, a chlorinated hydrocarbon; Weed B Gon, an herbicide containing esters of 2, 4-D and 2, 4, 5-T chlorinated phenoxyacetic acids; Malathion, a typical organophosphorus pesticide; and Sevin, a typical carbamate pesticide. The combustor was a ceramic vessel 6-1/2 in. ID x 20 in. long placed within a large clamshell furnace; it contained 15 lb of salt. The pesticide was added in such a manner that any gas formed during pyrolysis or reaction with the melt was forced to pass through the melt.

Several 10-gm polyethylene packets of each pesticide were treated. Nitric oxide, unburned hydrocarbons and carbon monoxide were measured during the tests. After the tests, benzene extractions of particulates collected in a glass wool trap and extractions of material collected in water scrubbers were analyzed to determine whether any benzene-soluble material containing the trace characteristic element of the pesticide (e.g., phosphorus for an organophosphorus compound) was emitted. All the pesticides were destroyed.

the analytical results indicating that much less than 0.1% of the original pesticide could have been present in the outlet traps. Analysis of the off-gases from the secondary burner showed less than 50 ppm NO_x , less than 10 ppm unburned hydrocarbons and less than 0.05% carbon monoxide.

ADVANTAGES OF THE MOLTEN SALT COMBUSTION PROCESS FOR DISPOSAL OF PESTICIDES

- 1) Destruction of the pesticide is complete
- 2) Pollutant emissions such as HCl , NO_x are minimal
- 3) No toxic products are formed
- 4) Combustion is more rapid than in conventional incinerators
- 5) Particulates are trapped by the salt
- 6) No water pollution since products are insoluble calcium salts and sodium chloride

ATOMICS INTERNATIONAL'S BACKGROUND IN MOLTEN SALT TECHNOLOGY

Atomics International has a thorough background in all aspects of molten salt technology, having had over 18 years experience in this field. This experience started with a basic program carried out over a 12-year period to study the fundamental properties of molten salts. This yielded a good understanding of the basic nature of molten salts, an insight into the chemical reactions of molten salts and served as a base on which an in-depth molten salt technology could be utilized in national problems.

In recent years, Atomics International has been applying molten salt technology to attack such problems as air pollution from stationary and mobile sources, solid waste disposal and, in addition, the overall problem

of providing sufficient energy capacity to meet the nation's growing requirements. These activities have resulted in a diversity of molten salt experience ranging from basic laboratory studies through engineering bench-scale tests and pilot plant programs. This background and experience can be characterized in terms of total expenditures. To date Atomics International has been funded on molten salt technology by various agencies for a total of \$9.7 million. In addition, \$2.4 million of corporate funding has been spent on these or related molten salt programs resulting in a total of about \$12 million.

The largest molten salt program currently underway is the Molten Carbonate Process for Removal of SO_2 from Stack Gases. In this process a molten eutectic mixture of lithium, sodium, and potassium carbonates is used to scrub the power plant gas stream. The sulfur oxides in the gas stream react with the carbonates to form sulfites and sulfates, which remain dissolved in excess unreacted carbonate melt. The resulting molten carbonate-sulfite-sulfate mixture is then regenerated chemically by converting the sulfite and sulfate back to carbonate and recovering the sulfur values as elemental sulfur. The regenerated carbonate is then recirculated to the scrubber to repeat the process cycle.

The Molten Carbonate Process for the removal of sulfur oxides from power plant stack gases was selected by Consolidated Edison from among 39 processes investigated for installation at the Arthur Kill Station on Staten Island. A \$4 million pilot plant, funded by Consolidated Edison, Northeast Utilities and Rockwell International, will process a sidestream equivalent to 10 electrical megawatts of plant output and will be in operation early in 1973.

Other molten salt programs currently underway for pollution abatement are:

- 1) "Removal of NO_x from Diesel Exhaust with Molten Carbonates" for the Rapid Transit District of Los Angeles which received a grant from the Department of Transportation.

- 2) "Molten Salt Combustion of Coal," a jointly funded program by Northeast Utilities and Rockwell International.
- 3) "Removal of Lead from Automobile Exhaust with Molten Carbonates," funded by a tetraethyl lead producer.
- 4) "Disposal of Explosives and Propellants with Molten Salts," funded by the Naval Ordnance System Command.
- 5) "Recovery of Metallic Silver from Photographic and X-ray Film with Molten Salts" funded by the Naval Ordnance System Command.
- 6) "Copper Metal Recovery from Scrap Wire with Molten Salts," company-supported.
- 7) "Municipal Waste Disposal with Molten Salts," company-supported.

ATOMICS INTERNATIONAL'S BACKGROUND IN MOLTEN SALT COMBUSTION

In addition to existing bench-scale units, two large scale combustors are beginning operation. These combustors are being used to obtain data from which prototype or commercial plants can be designed.

The first molten salt combustor has been erected at the Atomics International Santa Susana Facilities. The combustor vessel is 8 ft high and 3 ft ID and contains melt to a depth of about 3 ft. The system can operate at up to 100 psig. The combustor contains about 1 ton of salt and is capable of combusting about 250 lb/hr of coal. It is anticipated that the following processes will be tested in this combustor: coal combustion for power production, municipal waste disposal, disposal of low level radioactive waste, recovery of silver metal from photographic and x-ray film, and disposal of pesticides and other hazardous materials.

The second combustor is being used to carry out the reduction of sulfate to sulfide with carbon in the Molten Carbonate Process for removal of SO_2

from stack gases. To supply heat for this endothermic reaction, carbon is combusted in the melt while reduction is taking place. This reducer-combustor has been constructed for the Molten Carbonate Process pilot plant at the Consolidated Edison Company, Arthur Kill Station. Debugging is virtually complete and operation will be underway in May 1973. The reducer-combustor is 7 ft ID and 16 ft high, will contain 5 to 6 tons of salt and will burn 240 lb coke/hr to supply heat for the reduction step.

In addition to these units process engineering studies have been completed on a mobile unit directed specifically to pesticide (and container) disposal. The first chart indicates how this unit would be used. The second chart gives a plan and elevation of the unit and the concluding table gives costs for a first unit. Following a demonstration run on the Santa Susana Combustor, Atomics International is prepared to offer these units for sale.

For further information call

W. V. Botts (213) 341-1000, Ext. 1978
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8900 DeSoto Avenue
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TYPICAL OPERATING MODE (MOBILE)

- TRANSPORT TO SITE 1 WEEK
- CHARGE AND START-UP 1 WEEK
- OPERATE AT 500 lb/hr 1 TO 2 MONTHS
- DISPOSE OF ASH AND INSOLUBLE PRODUCTS AT
LOCAL SANITARY LAND FILL CONTINGENCY
- SHUT DOWN AND PREPARE FOR MOVE 1 WEEK
- MOVE TO NEXT SITE 1 WEEK

LOGISTICS SUMMARY

PREPARATION TIME ~4 WEEKS/SITE

OPERATION TIME 1 TO 2 MONTHS/SITE



REMOVABLE EXHAUST STACK

COOLING WATER JACKET

V-1

H-1

PREHEATER

GAS TRAIN / STRUCTURAL SUPPORT

S-1

MOTOR

ELEC. CONTROL

SW

STAGE M

TRANSITE

SAND SHOE

C-1

ELEC. CONT. TO POWER SOURCE

TRAILER BED

WHEEL

86'-0"

9'-10"

PLAN

SIDE ELEVATION

[illegible]

PRELIMINARY COSTS FOR MOBILE PESTICIDE (AND CONTAINER)

DISPOSAL UNIT - FIRST PLANT

CAPACITY \approx 500 lb/hr

	<u>(\$)</u>
EQUIPMENT AND INSTALLATION	190,000
PROGRAM MANAGEMENT	21,000
ENGINEERING	<u>145,000</u>
TOTAL	356,000

MICROBIAL DEGRADATION

Eldon P. Savage

The Committee responsible for this Conference on Chemical Waste Disposal should be congratulated for developing an interesting program. The continuing technological progress and improvement in methods of manufacturing, packaging and marketing of pesticides has resulted in an ever-mounting increase and diversity in the characteristics of solid wastes. Estimates of present solid waste production per capita range from 5 to 9 pounds daily. Municipal government cost analyses reveal that only 21 percent of the monies allocated for solid waste management are expended for solid waste disposal.

Although solid wastes disposal can be accomplished through composting, incineration, hydropulping, pyrolysis, recycling, or burial, the primary method in use in the Rocky Mountain area is land disposal.

Due to the predominance of poorly operated landfills in the Rocky Mountain area and the accompanying lack of preplanning and expenditure on the proper operation and maintenance of the disposal sites, chemical pollution emanating from these sites is an area of prime concern to the maintenance of environmental quality.

Pollutants from improperly disposed pesticides may contaminate the ecosystem through both air and water. The pollution of water, in the form of leachate, or drainage, appears to be a major problem. Through this vehicle, pollutants may be transported in solution or in suspension from the pesticide disposal site. Below the disposal site, dissolved material from the entire drainage area may be concentrated into the drainage system. Users of these waters for drinking water sources for animals or for irrigation purposes may be unaware of the chemical hazards.

Another major problem associated with contamination from waste disposal sites may be the buildup of concentrations of pollutants in the food chain. Biological concentration in the upper levels of the food chain cause some of the more persistent types of pesticides to reach dangerous levels in the individual organisms.

You probably remember that during the period of 1953 to 1960 a total of 121 people living near Minamata, Japan were poisoned from fish having high concentrations of methylmercury obtained from waste products containing mercury dumped into Minamata Bay. The mercury entered the food chain and the human poisoning cases resulted.¹

More recently in Alamogordo, New Mexico, mercury treated seed discarded outside an elevator was collected by a farmer and later fed to his hogs. When the hogs reached slaughter size, he slaughtered one and after his family ate the pork, some members became acutely ill from mercury poisoning. The mother was pregnant at the time and the baby she later gave birth to, was born with serious after effects. These two incidents exemplify some of the responsibilities we are talking about when we discuss disposal of pesticides.²

Pesticide sales and the volume of pesticides used have increased dramatically since World War II. During this 30 year period, pesticide wastes have frequently been disposed of in a careless manner and it is a miracle that we have not experienced more serious problems from careless waste disposal than we have during this period of time. Prior to the advent of modern pesticides, some microbiologists had thought that soil bacteria would degrade most environmental chemicals but some pesticides, including many of the chlorinated hydrocarbons, have proven to be very resistant to degradation. In microbial degradation, the pesticide

is used as a microbial energy source.

Normal soil microbial populations generally range from protozoa through the bacteria. (Table One). Any time we can increase the factors that accelerate growth of microorganisms in the soil, we may be able to speed up the microbial degradation. Researchers at Oregon State University working on the disposal of selected pesticides found if you increased the moisture content of the soil, and adjusted the pH, you could accelerate the microbial activity in the soil.

Most of the work done to date on microbial degrading has been done in laboratories and only limited research has been done where there is microbial interaction with more than one species of bacteria involved. This is one aspect of degrading that needs further clarification. Other factors that affect microorganisms in the soil are shown in Table Two. These include temperature, moisture, ionic composition, and related microbial growth factors.

Review of the degrading rate of p,p'-DDT to p,p'-DDD by bacteria under aerobic and anaerobic conditions as shown in Table Three. Under aerobic conditions for 14 days there is very little or no degrading or decomposition, but for several species of bacteria there are rather high levels of aerobic activity in a fourteen day period. Some give as high as 48.8% breakdown. In evaluating the 27 bacterial species for their ability to degrade p,p'-DDT, the conversion of DDT to DDD occurred most actively during the second 7-day period of incubation under anaerobic conditions."

It is worthwhile for us to review the fundamental types of oxidation processes; loss of hydrogen, oxidation by the addition of oxygen, using sodium chloride and oxidation by the loss of electrons. All three of these processes of oxidation are important in decomposition of pesticides.

Aldrin, endrin, and dieldrin can be dehydrochlorinated by merely adjusting the pH to below 3. Potassium permanganate, as an oxidizing agent, can also speed up the microdegrading of some pesticides.

The decomposition and period of persistence of herbicides is also interesting. The reason that I am including a few slides on herbicides is not because we know a great deal about them but because the states that you people represent use a large volume of herbicides. Table Four shows the decomposition and period of persistence of several herbicides. Monuron takes four to twelve months to decompose and the active organism is *Pseudomonas*.⁵ The range of persistence of herbicides in soil varies from two weeks to twelve months.

The structural formula of the herbicides 2,4,5-Trichlorophenoxyacetic acid and 2,4-Dichlorophenoxyacetic acid are shown in figure 1. Although the only structural difference you will note is an additional chlorine in 2,4,5-T, decomposition of 2,4-D and 2,4,5-T presents a completely different story. Microbial decomposition of 2,4-D and 2,4,5-T is shown in figure 2. Note the relative herbicide concentration of 2,4-D drops rapidly in a 10 day period while the concentration of 2,4,5-T remains quite high during the 20 day period. Even under optimum conditions 2,4,5-T remains in non-sterile soil for periods of six months to a year or longer.⁶

Most land disposal plans are designed for a cell depth of usually 6 to 8 feet. A second parameter is a width generally at least twice the width of the tractor for maneuverability. A third operating parameter is you must compact refuse continuously.

These plans also call for 6 inches of daily cover with a final cover of 2 feet. This type of landfill design probably doesn't lend itself to

the best degrading of chemicals. If you look at the soil depth in centimeters of a normal soil profile, and at the anaerobic bacteria which are important for decomposition you'll notice that as the depth increases to a level of 40 cm you obtain only limited degrading. Most microbial degrading is accomplished in the extreme upper soil levels, but what we have been doing for the last 40 years is burying waste products as deep as we can without contaminating ground water. At Colorado State University, a graduate student has been studying the biodegradation of p,p'-DDT and aroclor 1254 in soil obtained from the Fort Collins Solid Waste Disposal Site.⁷

The rate of microbial degradation of p,p'-DDT and Aroclor 1254 inoculated into alfalfa-amended and nonamended soil from the site was recorded over a twenty-two week period. The inoculated soil samples were waterlogged and incubated at 30 C for the duration of the experiment.

For purposes of comparison, all soil samples were analyzed by electron capture gas-liquid chromatography and quantitated by comparing the peak height of the sample to the standard's peak height. A method of qualitative-quantitative analysis of Aroclor 1254 is also presented.

The p,p'-DDT was moderately degraded in both the alfalfa-amended and nonamended soils, however, there was no significant difference in the rate of degradation between the amended and nonamended soil preparations. No significant degradation of the Aroclor 1254 occurred over the twenty-two week period and likewise there was no difference in the degradation rate between the Aroclor 1254 amended and nonamended soil. (Table Six).

All four soil preparations had microbial cell counts characteristic of a fertile soil at the end of the twenty-two week period. The Aroclor

1254 soil preparations had significantly greater populations than the p,p'-DDT soil preparations. There were no significant population differences between the amended and nonamended soils for each of the chlorinated hydrocarbons. Therefore, the alfalfa amendment did not induce cell growth and proliferation in the soil. Seven different genera of microorganisms were isolated from the soil and identified.

Table Seven depicts the factors affecting microorganisms in soil. All of these are very important in obtaining breakdown of environmental chemicals. For the past thirty years many farmers in the United States have disposed of used pesticide containers by using them to fill in small ravines in an effort to stop land erosion. Unknowingly, they may have been following some aspects of successful chemical waste disposal. They have placed the pesticides at a shallow depth in areas of high organic load, in areas where microbial breakdown should be quite high. I would hope in the future that we can conduct enough applied and basic research to develop some answers to this tremendous problem of pesticide waste disposal by microbial degradation.

TABLE ONE

SOIL MICROBIAL POPULATION

1. Bacteria
2. Actinomycetes
3. Fungi
4. Algae
5. Protozoa

TABLE TWO

FACTORS AFFECTING MICROORGANISMS IN THE SOIL

Substrates

Mineral Nutrients

Growth Factors

Ionic Composition

Temperature

Pressure

Radiation

Moisture

TABLE THREE

Degradation of p,p' DDT (100 µg DDT per 10 ml culture fluid) to p,p' DDD by bacteria.

Bacterial species	Concentration of DDD (µg)	
	Aerobic (14 days)	Anaerobic (14 days)
Control, media	N	N
<i>Achromobacter</i> sp.	N	44.7
<i>Aerobacter aerogenes</i>	N	11.4
<i>Agrobacterium tumefaciens</i>	N	30.9
<i>Azotobacter</i> sp.*	N	
<i>Bacillus cereus</i>	T†	14.3
<i>Bacillus cereus mycoides</i>	T	20.4
<i>Bacillus subtilis</i>	T	34.6
<i>Clostridium pasteurianum</i>	S.A.	27.4
<i>Clostridium sporogenes</i>	S.A.	N
<i>Corynebacterium michiganense</i>	N	T
<i>Erwinia amylovora</i>	N	28.1
<i>Erwinia ananas</i>	N	42.9
<i>Erwinia carotovora</i>	T	45.3
<i>Erwinia chrysanthemi</i>	N	32.4
<i>Erwinia</i> sp.	N	50.1
<i>Kurthia zopfii</i>	N	27.0
<i>Pseudomonas fluorescens</i>	N	31.9
<i>Pseudomonas glycinea</i>	N	48.8
<i>Pseudomonas marginalis</i>	N	7.8
<i>Pseudomonas mors-prunorum</i>	N	32.6
<i>Pseudomonas syringae</i>	N	40.8
<i>Pseudomonas tabaci</i>	N	23.2
<i>Sarcina lutea</i>	N	N
<i>Xanthomonas pruni</i>	N	5.7
<i>Xanthomonas stewartii</i>	N	54.4
<i>Xanthomonas uedovorus</i>	N	48.6
<i>Xanthomonas vesicatoria</i>	N	8.1

* Grown only aerobically. † 1 to 2 µg. N=None. T=Trace. S.A.=Strict anaerobe.

TABLE FOUR

Decomposition and period of persistence of several herbicides

Herbicide	Persistence in soil	Active organisms
Monuron	4-12 months	<i>Pseudomonas</i>
Dalapon	2-4 weeks	<i>Pseudomonas</i>
DNBP	2-6 months	<i>Pseudomonas</i>
TCA	2-9 weeks	<i>Pseudomonas</i>
4-CPA	4-12 months	<i>Achromobacter</i>
2,4-D (Acid)	2-8 weeks	<i>Achromobacter</i>
MCPA	3-12 weeks	<i>Achromobacter</i>
4-CPA	4-12 months	<i>Flavobacterium</i>
2,4-D (Acid)	2-8 weeks	<i>Flavobacterium</i>
2,4-D (Acid)	2-8 weeks	<i>Corynebacterium</i>
DNBP	2-6 months	<i>Corynebacterium</i>
DNOC	2-6 months	<i>Corynebacterium</i>
MCPA	3-12 weeks	<i>Mycoplana</i>
Dalapon	2-4 weeks	<i>Agrobacterium</i>

TABLE FIVE

SOIL PROFILE AND DISTRIBUTION OF MICROORGANISMS

<u>Depth (cm)</u>	<u>Aerobic Bacteria</u>	<u>Araerobic Bacteria</u>	<u>Actinomycetes</u>	<u>Fungi</u>	<u>Algae</u>
3-8	7800	1950	2080	119	25
20-25	1800	379	245	50	5
35-40	472	98	49	14	0.5
65-75	10	1	5	6	0.1
135-145	1	0.4	-	3	-

TABLE SIX

Breakdown of DDT and Aroclor 1254
(Percent recovered of initial 100µg/g soil)

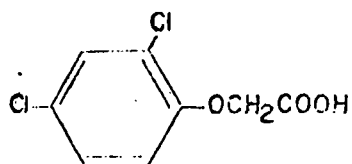
	<u>Incubation Period (in weeks)</u>		
	<u>3</u>	<u>6</u>	<u>22</u>
DDT Amended Soil	82.21	70.71	63.53
DDT Non-Amended Soil	76.97	73.40	75.74
1254 Amended Soil	93.57	83.96	79.27
1254 Non-Amended Soil	96.89	86.81	75.14

FIGURE 1

2,4-D

chemical name: 2,4-dichlorophenoxyacetic acid

structural formula:



2,4,5-T

chemical name: 2, 4, 5-trichlorophenoxyacetic acid

structural formula:

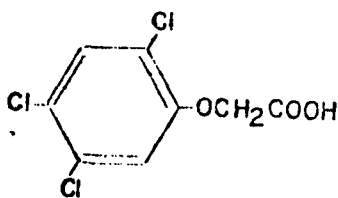
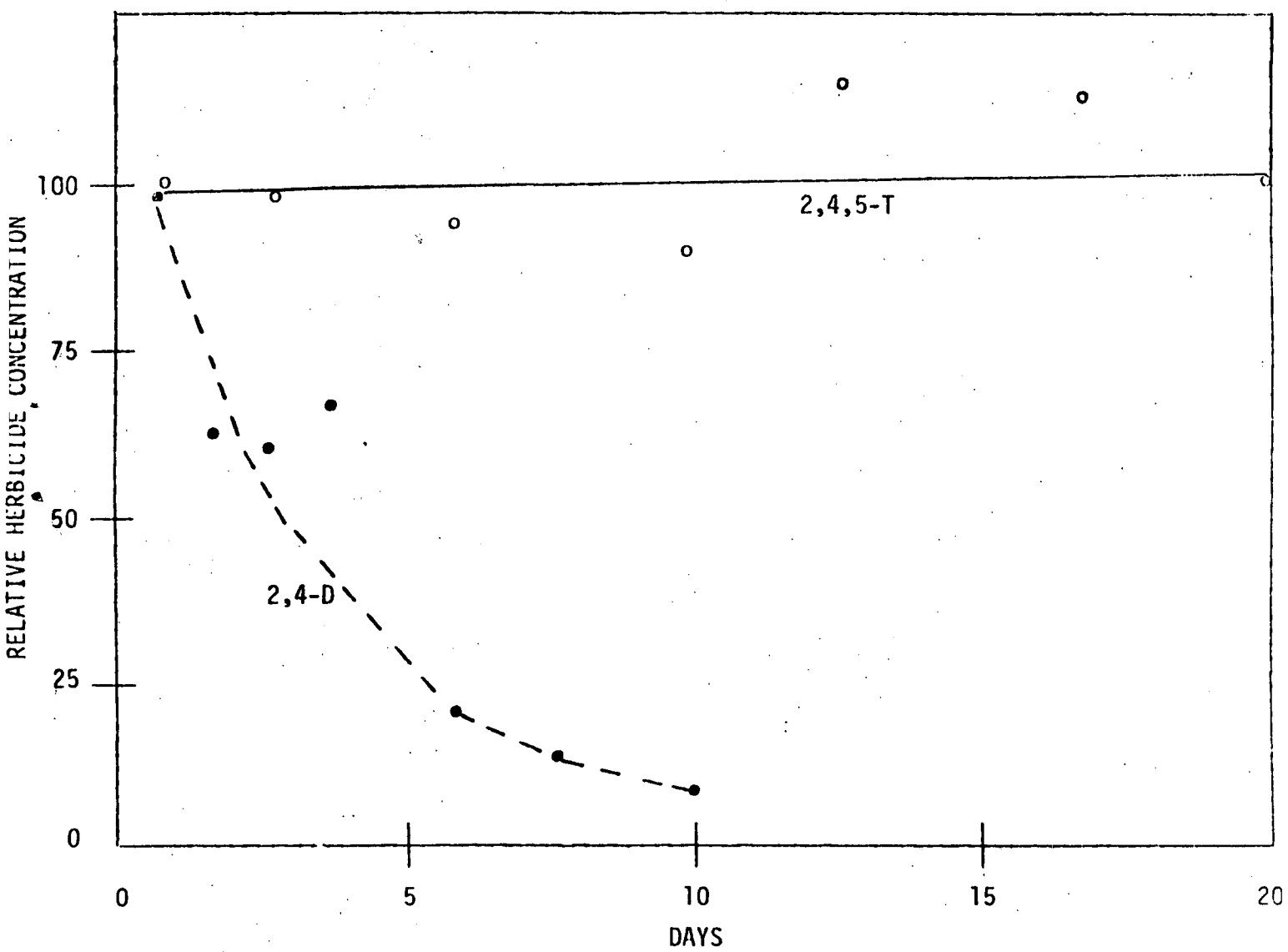


FIGURE 2



Microbial decomposition of 2,4-D and 2,4,5-T in soil suspensions.

California Collection, Transportation, and Disposal Systems

Dr. Robert M. Pratt

If you're counting on me to tell you how we've solved all problems in California, we're in trouble. The thrust of my message is . . . this is what we've gone through and I hope you won't have to go through all the same things. We have been going along for some time and haven't solved all our problems, but maybe we're pointed in some directions. I've enjoyed being with you so far and participating in this down to earth conference with the emphasis on problem solving.

I'm aware that people in other states get tired of hearing how great everything is in California. In fact, when I was a graduate student at Cornell, my fame was based mostly on the fact that I never mentioned California except by invitation. Nevertheless, I think I'm going to have to give you a little background to give you an idea of the scale on which we operate.

California agriculture produces 25% of all the table foods and over 40% of all fresh fruits and vegetables consumed in the United States. We have over 200 crops. We are the first or sole producer of 50 or more crops such as almonds, apricots, avocados, and olives. We are very big in cotton, sugar beets, and feed grain. Nearly all of the fruits and vegetables and all of the cotton and much of the grain is irrigated. This all adds up to a high-cost, high-yield, agricultural industry requiring heavy pesticide use. So it is not

because we're pesticide happy that we use 20% of the national total. Our problem is further complicated by the fact that our crops are intermixed to a considerable degree. We became experts early on DDT problems and put DDT under regulation as early as 1963 because of contamination of alfalfa by DDT used on cotton. The best estimate I can make is that we used 116,000 pounds of pesticides, active ingredients, in 1971-72.

I think I should also give you some idea of the California enforcement structure. The California Department of Food and Agriculture, as it has been officially known since March 7, has about 1,400 full-time employees, with a peak of 2,200 in the summer time. We're into marketing, animal health, all of the usual plant industry things, fruit and vegetable standardization, and many other areas, as well as pesticide control. We've been active in pesticide enforcement for a great many years. During the past four years, each year, the legislature has passed one or more measures to give us additional powers. In the field of pesticide regulation, we have 45 people in our agricultural chemicals unit, which is the field enforcement unit. We have about 100 man-years equivalent in the offices of the County Agricultural Commissioners. This, I should stress, is one of the unique ways we operate in California. Each county except five nonagricultural counties has a County Agricultural Commissioner and staff. These people operate under state law, under the general guidance and direction of the State Department

of Food and Agriculture, but they are paid by (and therefore ultimately responsible to) the County Board of Supervisors. This organization gives us local sensitivity and awareness of problems that we cannot possibly have at the state level. We also have about 25 man-years of work in our chemistry laboratory on pesticides. This totals 170 man-year equivalents in pesticide enforcement.

We have developed quite a body of laws and regulations, and at this point I come to the packet I have handed out. After the leaflet on the rinse and drain procedures, the first one is the summary of California law. I call your attention specifically to the last page, Section 12991, paragraph e: "It is unlawful for any person to store, transport, handle, or dispose of any economic poison or of any container which holds or has held such economic poison, except in compliance with rules and regulations of the director." So this ultimately is our authority to manage pesticides and their containers. We did not have specific authority over containers until a bill was passed in 1969.

The next document is entitled, "Agricultural Chemicals and Feed Regulations Concerning Agricultural Pest Control," and I direct your attention to page 36, Article 10, "Storage, Transportation, and Disposal." This, and the rest of the pages to the end of the document, are the regulations which we have implemented as of March 1 to carry out the law that I called your attention to previously. I'm not going to dwell on these things, they are something you can read at your leisure and perhaps make some use of in your discussion groups. Incidentally, I

brought the whole summary of our pesticide law and all the regulations, including those not strictly related to disposal and containers, so that you would have the picture of the whole situation in which we operate.

The next document contains the regulations of the Air Resources Board, specifically on agricultural burning. The first paragraph on the front under the heading, "Agricultural Burning Guidelines," says, "Agricultural burning means open outdoor fires used in agricultural operations in the growing of crops, or raising of fowls, animals, forest management, and range improvement." On the next page, paragraph b says, "This includes the burning of material not produced wholly from such operations but which are intimately related to the growing or harvesting of crops and which are used in the field, including pesticide sacks and containers." More on that later.

On page 10, it provides that the district air pollution boards can regulate or permit the burning of materials in agricultural operations: "In developing the rules and regulations, each district shall have additional provisions," etc. That's paragraph c, and then in number five under c, it says they may permit, on no-burn days, the burning of combustible pesticide containers or other toxic substances provided that it is within the definition of open burning in the field.

The next document is from the State Water Resources Control Board. This defines the disposal sites and the kinds of wastes. In Article 2 near the bottom, "Class I disposal sites are those at which complete protection is provided for all time, for the quality of ground and

surface waters from all wastes deposited therein, and against hazard to public health and wildlife resources." And it goes on to define the geological conditions which are pretty restrictive, because a Class I site is one in which you can put anything. It includes things like acid waste and chromate waste and all sorts of disagreeable things that are really a bigger problem than pesticides.

Near the bottom of the second page, you find the heading, "Class II Disposal Sites." There are Class II Sub 1 sites which overlies usable ground water, but the geology prevents a lateral-vertical hydraulic continuity. Class II Sub 2 sites are those having vertical and lateral continuity but which are somewhat protected. And, finally, there is the Class III site in which you can put only old concrete, asphalt, tires, and other nonsoluble waste.

On page four, you'll find under group-one wastes, paragraph c, "Chemicals such as pesticides or chemical fertilizers and discarded containers of chemicals, unless adequately cleansed." The unwanted chemicals themselves are restricted to a Class I site; the discarded containers, not adequately cleansed, can go into a Class II Sub 1 site, in other words, a selected site. Adequately cleansed pesticide containers can go into a Class II Sub 2 site which is actually a general landfill disposal site. As I said, the only thing less restrictive is the site for old concrete. So if we get the containers rinsed, we've got quite a bit of freedom.

Next comes a one-page document I'm not going to dwell on, except to point out that this is something that is just now in process. We are moving strongly into a rinsing program as I shall come back to, and this is a set of guidelines our task force is about to adopt on adequate holding sites pending final disposition.

There are three other agencies I should mention as being immediately involved. The first is the Department of Public Health, Solid Waste, and Vector Control, which has a great deal to say about the characteristics of solid waste disposal sites, mostly from the human health standpoint. The Water Resources Control Board has the say as far as their effect on the ground water and surface runoff. And finally, the California Highway Patrol regulates highway transportation. They have adopted the Department of Transportation regulations as applicable in California.

Now with that legal background, I will go on to tell you that two years ago last December we began what is now the Interdepartmental Task Force on Pesticide Container Disposal of which I happen to be chairman. At the beginning, we met with the Water Resources Control Board and the Air Resources Board representatives and we've now expanded our membership to include the Department of Water Resources, the Department of Public Health, Solid Waste, and Vector Control, and the Department of Consumer Affairs, Structural Pest Control Board. We brought in the Department of Industrial Safety, the California Highway Patrol, and the University of California Agricultural Engineering and Pesticide Program. We have

a representative of the California Agricultural Commissioners Association. We've invited the Department of Fish and Game, but their response essentially was, "You keep the cans out of the creek and we won't have any problems."

The main thing this group accomplished, in my mind, is that gradually we have got all of the named agencies to accept this problem of pesticide containers and surplus pesticides, which we're handling on the side, as their problem. Initially, each little jurisdiction was sitting behind its own barbed wire entanglement saying, "Our job is to keep our part of the environment clean and pesticides are your problem." So, my advice to all of you is get everybody on board at the outset and you'll have a lot less trouble later on. We've done a few finite things to get everybody pulling together. We started off "gung ho" with a clean-up program. Industry volunteered through the Aircraft Operators and Western Agricultural Chemicals Association to furnish transportation and the manpower to find all of the old containers and get them rinsed and into suitable disposal sites. We urged the people controlling the dump sites to get the cans in. This was the genesis of our getting to the point where a rinsed container could go into a Class II Sub 2 site. The idea was to clean up in late winter when the industry people weren't so busy hauling pesticides, and trucks were available. We worked with manufacturers, formulators, dealers, applicators, County Agricultural Commissioners, the University, including the Extension Service, and all the aforementioned state agencies. Industry

provided transportation, manpower, and some washing sites. Supervision was provided by the Agricultural Commissioners and some of the local Health Departments. We put out quite a lot of publicity and a packet of advice, and information went to all of the concerned local agencies and industries. I have a copy of the packet if anybody wants to see it.

This was not a complete success. Review of the results indicated that 18 counties participated, out of about 56 with Agricultural Commissioners. They collected 22,000 containers, a fairly small fraction of what we expected. Twenty-two counties reported they had other disposal programs going, in other words, they were already putting containers into acceptable disposal sites. Eight counties could not participate due to lack of disposal sites or washing facilities, and 12 counties had no problems. These were either nonagricultural counties or counties with handy Class I sites which they were already using. The biggest problems were a lack of cleaning facilities and convenient disposal sites. There were some communication problems among the agencies involved.

Let me note at this point that we do not recommend gathering and rinsing old containers; it doesn't work, as we found out the hard way. It's too laborious; it's too expensive; it's not particularly safe, and in addition, most of this stuff has dried in the can for a period of months. You're not going to get it out without a strenuous rinse program with alkalizers. You've then developed a whole new problem of what do you do with the rinsate. We don't recommend going that route for disposing

of old containers. In 1972, as a result of this experience, we did not organize a statewide cleanup, but we did put out a similar packet of information and suggest that problems be dealt with at the county level.

Coming to our present situation, I've called your attention to the regulations on containers without going into detail. The most important thing they say, aside from pointing out that containers, either full or empty, should be kept behind a locked gate, is that containers shall be rinsed at the time of use and the rinse water shall be put in the spray tank. This is our big thrust now. When you do this you're accomplishing several things. In the first place, you're saving the operator some money because he doesn't waste several ounces of very expensive material that stays in the can. In the second place, if you rinse the can when it is emptied, you can get it clean. Industry has run several tests on different materials. With the triple rinse which has been promoted by the National and Western Agricultural Chemicals Association, you can reduce the residue to the point where you're essentially dealing with scrap steel. I'm not sure who is entitled to the credit for this -- I might note in passing that we have adopted a lot of programs formulated by the industry and then said, "OK boys, get crackin'." This is one of them. We wrote into regulation the detailed procedure for triple rinsing. We don't

seriously expect that very many people are going to do that. It's too time consuming and perhaps not terribly safe, but it is something we could define and which we had researched.

The next paragraph says, "... or other equivalent method approved by the director," and that means as a practical matter the director will approve rinsing the container with some sort of jet system. We're now in the process of defining an acceptable jet rinse procedure. We will not certify individual devices because we figure every applicator is going to build one out of his own plumbing supplies, and most or all of them are going to work, and they will all be different. But we will specify that the device must wet the entire inside of the can and use at least half of the original volume of water. So this is the way we're going now, with triple rinsing at the time of use. The container then can go to any Class I or Class II site or, better yet, to scrap steel. I'm talking about metal containers, obviously. Glass containers should also be rinsed. Preferably, glass containers should be broken so that they can't be reused. This can be achieved fairly easily. With a 50 gallon drum handy, you just drop the thing in with some vigor, and the next one on top of it, and most of them are going to get broken. So you've got some recyclable glass that has been rinsed for safe handling.

We believe rather strongly that, although rinsed containers can go in an approved disposal site, as many as possible should be recycled. This is pretty good high quality scrap steel, and if the containers have been rinsed in the prescribed manner, there is no big safety problem in handling them. In this area, of course, I suspect your facilities for scrap handling may be a little bit limited and your transportation problems, I'm sure, are larger than ours may be. We (or Western Agricultural Chemical Association to be exact) are negotiating with a steel company in Oakland which makes structural shapes out of scrap steel. They will be quite happy to receive these rinsed containers. They compress them into a cube and drop this cube into molten steel at 2800 degrees F which will eliminate volatile products. With that temperature, you're not going to get much except carbon dioxide and water. So, we think that is an acceptable way if you've got a steel company within reach.

The other thing we're trying to do now is to get rid of the unrinsed containers and again industry volunteered to do this. The deadline has been set back a couple of times, partly because of the weather, but mostly because of the difficulty of finding suitable sites -- something you have been talking about all morning. It is a problem, as you know. The ideal dump site is one that is very handy to me as long as it's up somebody else's road and not mine. We ran into things like exorbitantly high costs. Some of these commercial dumps can make a lot more money receiving liquid wastes than empty cans. We run into situations where the man at the gate

reads the label and if it says, "flammable," he won't take it. We finally broke through that, but it took awhile.

Last but not least, in the San Joaquin Valley, which is our biggest collection of all, Fresno County has been developing a Class I site near Colinga on the east side of the coastal ranges. There's been delay after delay after delay, and everybody's been sitting around waiting for the Fresno Class I site. We hope it's going to be available in another month. Of course, by that time, the crops are going to be growing and the people are going to be selling pesticides and they're not going to have time to haul containers. I don't know how we get out of that one. However, we did think we had a scheme going in that we have discovered a scrap dealer who bales up scrap and ships it to Japan. The Japanese are willing to accept this scrap steel. The difference between this operation and the Oakland steel mill that I referred to earlier is that the exporter feels there is no personnel hazard in their materials handling process. The Oakland mill would take unrinsed containers, and they feel there would be a little more personnel hazard. The catch is that right now scrap steel is in very great demand. Most of the scrap going through the Stockton outfit that ships to Japan is shredded; we all agree that unrinsed containers should not be shredded in their nonenclosed setup because of possible air and water contamination as well as personnel hazards. They're just too busy shredding automobiles to run containers through their press. So, like most things in life, you get crossed up by something which has nothing to do with what you're trying to accomplish at the moment.

We've not uncovered a big problem on surplus pesticides; they can go into a Class I site. Some of the chemical companies haul material to an approved site in Nevada, thereby exporting our problem. We think we have a handle now on the future accumulation of containers by putting them through the rinse and drain procedure at the time of use. So right now when we get, hopefully, all of the present dirty containers cleaned up, we're going to be in the business of handling these rinsed containers, which are essentially just so much scrap steel. We have a pilot project in Kern County where, with industry cooperation, four collection sites are located on county land. These will be fenced, and are Class II disposal sites where there is some supervision. They are making a deal with the scrap dealers down there to keep these things emptied out so they have a product which somebody will carry off for them or may even pay for. Right now, they are happy enough if they just take them away for free. So this is about where we are, and, as I pointed out earlier, there is a set of specifications that we will presumably adopt for these collection sites.

Now, I'd like to emphasize a little more that we have leaned heavily on industry. I mean that in two senses; we've depended on them; we've also leaned on them a little bit in the other current sense. They are really responsible for the triple rinse program and they are publicizing it and putting out these posidrain tools. I have one with me in case you haven't seen one. It's sort of a king-sized beer can opener. A lot of the chemical supplies are giving these away to their customers. The

posidrain has two advantages: it makes the container unusable for other purposes, and it makes a little flap and presses it tightly against the side of the can so it can be drained more completely. We're not very strong on crushing. There are a number of crushers, homemade and otherwise, being used around the state and it may or may not be advantageous. Again, if the containers are crushed, they are unusable and you get more of them on a truck until you get up to your weight limits.

At this point, I want to stress our indebtedness to industry for recognizing the problem. The policy of the Western Agricultural Chemicals Association is to solve the problem without increasing costs to the chemical industry per se, or to agriculture and therefore to all of us. Most of these things, like recycling the drums and eliminating some of the less desirable containers, can be done at no cost.

Now I would like to direct your attention to a summary of what we have done and what we are thinking about. This really stems from the Sherman Oaks Conference of August 1 that several of you have referred to. We agreed at that conference with the Environmental Protection Agency that we were going to prepare a set of proposals. This is it and we have distributed it pretty widely. Some of you may have seen it already because the Western Agricultural Chemicals Association sent it out. You'll note we start off by summarizing the magnitude of our problem and the materials. We tried to break the problem into three components: (1) to prevent the further accumulation of empty pesticide containers

(I have described this to you in part in our rinsing program);
(2) collection and disposal of already existing empty containers
(I have told you about our successes and failures in that); and
(3) the long range solutions including recycling, incineration
techniques, and we should have had biodegradation in there too,
because it is something we have talked about quite a bit.

So then we go on to break up the responsibility among the
California agencies, starting with further regulations needed, and
this we have already done. Going to page three, I mention structural
pest control operators.

We have not really done much about home use containers, which are
pretty important to us because of our large urban population. What
we hope for there is more education. We don't permit anything very
toxic anymore, to be put in home use packages. We're leaning on the
University a little bit to put statements in their bulletins on care
of the home garden and on the best way to get rid of these home use
packages. Incidentally, there is not much you can do with an aerosol
can except drop it in the trash; maybe it's nice to put it in a plastic
bag first. Bottles should be rinsed the same as commercial containers.
Also, we are working with industry on better labeling and this is, of
course, a place where the Environmental Protection Agency gets into the
act because they've got the last word on labeling. Ditto for disposal

instructions on the label, which again, I think EPA wants to think about. I've told you what we're doing about the central collection sites for rinsed containers and this we're handling with the Department, Agricultural Commissioners, and industry. Concerning color coding, we're pretty well back to EPA again because this obviously should be done on a national or international basis. Industry tells us they don't want the container a different color for each pesticide or each class of hazard. The reason for this is they don't really know at the beginning of the year how many containers they are going to need for pesticide "X" and how many for pesticide "Y" and how many for pesticide "Z." However, they would be responsive to a scheme for having all pesticide containers the same color, say, a nice bright chrome yellow. Well, maybe the "ABC Food Company" is packaging salad oil in chrome yellow drums, but it seems to me fairly obvious that if we point out to the "ABC Food Company" that all pesticide containers after a certain date, are going to come in chrome yellow drums, they would decide rather quickly to put their salad oil in purple drums or something else. I think that can be dealt with. Industry is also willing to have the labels colored by class of hazard, because you can manipulate the labels more easily than the supply of drums.

We're trying, through the Department and industry, to keep a running inventory of the number of containers in storage and use. I might mention we have an elaborate computerized system for reporting

all the pesticides that are used in the state. We can now tell you with some accuracy what is being used on what crops and whether it's correct or not.

Concerning the prevention of further accumulation, I've told you about the rinsing regulations, the triple rinse, and the promotion of the jet rinse. Industry is moving towards standardized packages. This is another one of these enlightened self-interest moves. We would like very much to get rid of paper packages. We recommend at this time that the best way to get rid of paper containers is to burn them in small numbers at point of use. Now, of course, we're quite aware of all of the limitations on burning paper packages, including the smoke and the pesticide fumes and the possible ash problems. But, we are also aware that there isn't any good way to pick these packages up and move them to a disposal site or an incinerator or anything else. If you try to gather them up, you're going to get a face full of dust. If you stuff them in plastic bags so they can be moved over to the highway without leaving a trail of dust, you're again going to get a face full. We do not encourage accumulation and burning of large piles and certainly not burning in any urban environments. The Air Resources Board does not fully share our enthusiasm for this method of disposal, I should add, and so this is an area where we're not terribly happy about current disposal practices.

Skipping to long range solutions, industry is talking to the steel companies about standardized drawn 1, 2, 3, 5, and 15 gallon steel

containers, not the usual kind with the top, bottom, and sides seamed. There is an unpleasant statistic that I just acquired a couple of days ago: ten percent of the standard steel pesticide containers leak. Ten percent! This is an appalling figure when you consider how many of them are going over the road. Of course, we're fairly nasty in California about moving pesticides and food on the same truck, because there have been a few unfortunate episodes, so it is now illegal. If they have a drawn container, it will not only clean better, but will also reduce the leakage problem. Industry feels they can do this at no real increased cost. We are recommending the 30 and 55 gallon sizes be limited to returnable use only. In other words, many of the herbicides and spray oils can be sent out in drums and the drums reused. The smaller packages are not practical to reuse because of cross contamination, leakage problems, and all the rest. Incidentally, our rinse and drain rules only apply to containers of 28 gallons or less. We are allowing for the return of larger containers.

We and industry recommend eliminating the use of glass and plastic jugs and paper containers as rapidly and as completely as possible. There are some materials that have to be in glass and that's why I referred earlier to recycling glass. They are adopting an amber colored gallon jug and recommending, as I said, breaking them so all us photographers can't take these nice brown jugs home to put our solutions in. We're also urging the development of soluble packages or liners and most of

the companies are working on these for wettable powders. These are packets with a soluble plastic inner liner that you drop in the tank and an outer carton or wrapper of paper presenting no special hazard. There are some things like granules which we don't have an answer for at this time.

We are also interested in evaluating advanced systems of pesticide waste and used container disposal. This, of course, is where we get to things like the Rockwell gadget that we just heard about from Dr. McKenzie. He was rather tactful in attempting to describe our interest in it. Shall I say, we are cheering them on but we haven't any money. We are trying to outstall them and see if they will pick up the tab or maybe get the Air Force to pick it up or somebody who has money!

You've heard about the Rockwell gadget. Aerojet has one on paper which is essentially the insides of a jet engine in which they feed the materials. There are also others that are being tried that I don't know as much about. Incidentally, somebody mentioned the Chem Agro presentation earlier. The impression I got is, they don't operate at a high enough temperature to degrade everything into carbon dioxide and water. That is pretty limited and I don't think they are promoting it as a solution. We are very much interested in this, but we haven't any money so we're about to write to EPA again and see if we can get a grant out of them. There is, as some of you know, a meeting of military people right now in Washington to talk about this same thing and we have a representative back there.

We have listed some research needs that we've identified, some of which we are still thinking about, like reducing pesticide hazards in the home environment. Incidentally, the biggest hazard in the home environment is the guy who takes something home in a Coke bottle. I have known people, like park department supervisors and pesticide operators, to tell their personnel that if they must steal something, steal the whole can. Don't put some of it in a Coke bottle and take it home for your kids to drink. The poison information people will tell you that most pesticide deaths result from exactly that: the stuff is put in an inappropriate container. There are other ways, I hope, and we need to do better. We need more evaluation of what we're talking about. We lost interest in a research project on the design, testing, and evaluation of jet rinsing because I think all of our handy farmer mechanics are going to solve that one for us. Industry, of course, is working on all these alternatives.

A subject in which we have a continued interest, but again lack funds for, is to assemble and evaluate the existing information worldwide on the fate and leachability of pesticides in soils. There is a vast amount of information on this in the literature, most of it buried somewhere incidental to work on the control, say, of a given soil insect. There is a strong tendency on the part of water control people and others to assume that anything you put on or under the ground is going to go right into the water table. Well friends, it ain't so! I'm aware of things like lenses that the morning speaker mentioned and cracks and fissures and so forth, but many of my friends have devoted their lives to figuring out how to get a

pesticide to move more than three inches in the soil. Certainly, there are hazards that exist. They must be dealt with, and can't be ignored, but let's keep them in context and deal with the facts. We haven't found anybody yet who is willing to stand up and say there is no hazard. We need a better basis of fact -- possibly some additional research -- but first of all, let's consolidate the information we already have. And finally, we should classify pesticides in terms of relative hazard, and some of that has been done. There is a tendency to assume that all pesticides are equally horrible and any container that has had any pesticide in it must be treated as if it were made of solid cyanide or some such hyperbole.

In summary, mobilize all concerned agencies at the start. Get everybody into the act and get all their input; you'll need all the help you can get and you'll have less trouble with that old problem "NMH" if you get them in at the start. "NMH," in case you don't remember, means "not made here." I suggest that you promote a rinse program, and again I think I made it quite clear to rinse it right into the sprayer. You've then got a relatively clean drum, which we still don't recommend for use as stock troughs or barbeques, but at least it's safe to move into scrap steel channels or disposal sites. Recycle as much of the materials as you can. Get the existing containers into approved sites or into approved channels and finally, tailor your program to fit your own needs and your own realities, because what may be real in California is not necessarily real in Colorado or Wyoming or North Dakota. Thank you.

DISPOSAL FACILITIES

Harry W. Trask

The Office of Solid Waste Management Programs was given the responsibility for developing "regulations" for the implementation of Sec. 49(a) of FEPCA last fall. Some preliminary work had been done by EPA's Task Force on Excess Chemicals, but essentially we were faced with pulling together ideas from several sources. When we started developing the recommendations within the Task Force, we based our first one on incineration because we were told that is the only real ultimate disposal method that offers assurance of environmental safety. But then, as we began to look into that, we found that only some pesticides can be incinerated in a practical sense, and, as Captain Young told you yesterday, incineration of Dioxin requires temperatures over 2200° F., and there are others requiring even higher temperatures. So we were faced immediately with developing a means of separating pesticides which can be readily incinerated from those which can't. Our initial classification was into pure organics, the metallo-organics, and the inorganics, special landfilling for the metallo-organics (unless you can remove the metal atoms and then incinerate) and encapsulation for the inorganics which are really mobile in the soil. Encapsulation was also recommended for the organic mercuries, arsenics, cadmiums, leads, and all the inorganics, generally. That was

our simplified method of starting out with this complex problem. So far it has held up and it's probably what's going to be printed in the Federal Register sometime.

We have been getting a good deal of static as to why we did not recommend chemical degradation. I think yesterday we heard some of the reasons right here. First, there is no one single chemical degradation method we can recommend across the board. We have a vast array of pesticides to deal with; many chemical families, and they all react differently. If we recommend treatment with caustic soda, that would get some of them, but again, it doesn't get all of them. Activated charcoal will adsorb ions out of some pesticides and deactivate them. Again, however, it won't do for all, and a high concentration of the chemical tends to load up the charcoal so fast that it is not economical. Similarly, clays will adsorb these materials and hold them so that they are not very soluble, but are much more useful with dilute solutions and not very good for concentrates. So the chemical degradation method sort of fell by the wayside and we are saying now that it should be used only under the guidance of somebody that knows the specific situation, the specific area, and, just as important, what to do with the products that are found. Biological degradation falls generally in the same class; as Dr. Savage said yesterday, the degradation of DDT produces DDD (among other compounds) and

that is just as bad. So we have that problem facing us.

Now, let's talk about what there are in the way of facilities now in operation. It's a fairly short list; there are only three major commercial incinerating companies in the United States. The largest is Rollins Environmental Services, Inc., which has three plants, one in Logan, New Jersey (near Wilmington, Delaware), one in Houston, Texas, and one in Baton Rouge, Louisiana. The plants are all generally the same, with some differences in efficiencies of their scrubbing systems: there is a new venturi-type scrubber at Logan which has not yet been installed in the Texas and Louisiana plants.

Rollins now receives technical services from Dow Chemical which modified all three Rollins plants quite significantly recently. However, the question of safety of incineration in these (and other) plants has been raised--whether EPA really should recommend that those plants can be used to dispose of excess pesticides. We are convinced generally that they can. Rollins says it can guarantee 99% destruction. Well, EPA being EPA, feels it has to be pure, like Caesar's wife, so we can't except the 99%. Therefore, we are going forward with a test of the Logan plant and identify what products actually do come out of the stack. Now, we don't anticipate any organic pesticide degradation products, but we want to prove once and for all that there are no pesticides emitted.

The other two commercial operating companies that will accept pesticides for incineration, are Pollution Control Inc., at Shakopee, Minnesota, and Chemtrol Pollution Inc., at Model City, New York (in the Buffalo area).

Chemtrol has incinerated pesticides in liquid form only, and have not incinerated any solid pesticides. The problem is with their feeding arrangement, and they aren't particularly interested in gearing up for solids. They have about as much waste chemical disposal business as they want now. I guess if there were a large quantity of liquid pesticides in that area, they would be interested.

Pollution Control Inc., up in Minnesota, is like a June bride; they are getting really anxious, but they haven't done it yet. There have been problems in getting a permit from the State Pollution Control Agency, which apparently isn't convinced that pesticides can be incinerated safely.

There are some commercial landfill groups and some also offer chemical treatment. One of these is Chemwaste Inc., in North Carolina; another one is the Nelson Chemical Company in Detroit, Michigan; and another one in Michigan is Environmental Waste Control Inc. Significantly, there aren't any out here in this area. A reference was made earlier in the conference to Monsanto Company. Monsanto does have a very large incinerator near East St. Louis, Illinois, but they have resisted successfully doing any commercial incineration work here. Dow Chemical earlier did some incineration at their Midland plant, probably

one of the best such installations in the country. You probably have heard that the State of Michigan ran a collection program and Dow did burn up all of the DDT collected, did a good job of it, and didn't charge the State anything. But Dow isn't going to do that any more because the people of Midland got all bent out of shape over the incineration of everyone else's pesticides in their town; obviously, their environmental quality would suffer !!!

There are a few other special landfills in the country which accept hazardous waste materials and five are in California, most in Southern California. As Dr. Pratt told you yesterday the Fresno County Unit is going to be the first that is really in an agricultural area in California, and will be of some practical use in pesticide disposal.

Nuclear Engineering Inc. has a special landfill in Illinois. It is getting nearly filled up now, but will still accept some pesticides. However, the State of Illinois is considering whether it should allow hazardous waste disposal in that particular area because apparently some question has been raised about the hydrogeology. Which brings up a case in point, one which the state of Illinois is facing right now. That is, if you don't have a suitable disposal facility, you're going to have disposal where you don't want it. You may remember that back East last summer there was Hurricane Agnes. Among other things, it flooded an area in Pennsylvania where some dithiocarbamate

fungicides were stored. The company which owned the pesticides wanted to landfill them, and did get some buried in a trench in a nearby field. The insurance company, however, wanted to explore salvage possibilities, stopped the operation, loaded everything in a box car and shipped it to a distributor in Illinois. A federal pesticide inspector took a sample of this shipment and found it to be out of grade mainly because it was contaminated with water. Disposal was order by the Court and the Assistant U.S. Marshall hired the H&L Disposal Company, which got rid of the materials in an open dump near the Vermillion River. The State of Illinois finally learned about the operation, located the material, and found that there was a potential for the generation of substantial quantities of ethylenethiourea (ETU). Now ETU is a soluble compound and moves readily in water, including ground water, and it was moving. But the State Geology Department finally determined it would take something like 140 years to get to the Vermillion River, and about 40 years to get to the nearest well. On the basis of that, we recommended to Region V that the dump section containing the dithiocarbamate should be sealed off to prevent water movement into and out of that area, which would be more environmentally safe than moving the material. But the State of Illinois is now asking where to locate such a landfill. It believes there are going to be other such problems, and they want to be prepared.

Now another thing we in the Office of Solid Waste Manage-

ment have been looking at is whether we can safely dispose of pesticides in sewage sludge incinerators. Now this is an idea that was prompted by an announcement that polychlorinated biphenyls (PCB) could be safely disposed of in sewage sludge incinerators. One of the largest manufacturers of these incinerators, Envirotech Corporation, submitted some partial data which indicated that maybe it could be done. It isn't very conclusive. If it is possible to do this without interfering with the normal operation of the incinerator, then it opens a good deal more capacity. In fact, there is one near your area (Kansas City). Denver also had a sewage sludge incinerator, but the air pollution agency shut it down. With the newer, modern design units, the scrubbing devices are quite efficient, and with the multiple hearth incinerator types, it appears that more complete combustion is possible. These units will generate temperatures of above 2,000°F., above what is needed for most pesticides. The real question is whether the addition of a pesticide is going to upset the normal operation of the incinerator. Most of these incinerators are loaded to capacity almost as soon as they are operating. So if we put a quantity of pesticide in there and the heat of combustion of that pesticide raised the temperature too high so that the machine doesn't work well--clearly we are going to get lack of cooperation. So that is another series of test burns we are going to carry out this summer. We haven't picked the incinerator yet.

Some of our worst wastes are the mercuries and arsenicals and

other inorganics and we have pulled together a list of companies who will take mercury compounds for reprocessing. Out of the six on this list, only one takes organic mercuries. Several will take mercury sulfide for reprocessing. If anybody is interested in this list, I can supply you with a copy of it. It's going to be updated as we proceed into this area of hazardous wastes. You see, mercury is one of the top hazardous waste materials that has been identified within OSWMP and we are going to be doing a lot more work with it, including compounds other than pesticides, such as mercury batteries.

Essentially all of the arsenic is produced by the American Smelting and Refining Company in Washington, recovered from the smelting of copper ores that contain the arsenic. By cooling the air, arsenic drops out as a particulate in bag filters. Being a by-product of copper operation, there is plenty of it around and not many people are all that interested in reprocessing it.

Is anybody here familiar with the episode in Minnesota regarding arsenic? Thirty years ago in Perham, Minnesota, a grasshopper control program was carried out. There was some poison bran bait (lead arsenite) left over and it was buried on a farm in accordance with pesticide disposal methods of that time. It was buried deep enough and in the right place, so they thought. But this last spring the farmer was taken to the hospital with arsenic poisoning, and tests showed there was 12,000 ppm arsenic in his well. The material had moved something on the order of of 1,000 yards in 30 years. Now the question is what to do with the contaminated soil? The State

of Minnesota is wrestling with some pretty tough problems. The soil is contaminated with arsenic and probably with lead too. It raises some questions about landfilling we don't have good answers to, and it also raises some questions about burying containers in the field. In writing our "regulatory" package we felt generally that farmers ought not to bury their containers indiscriminately in the field, and we got all kinds of static from farm groups. Well, when lead arsenite moves that way in the soil, if the container is buried without any real regard to where the underground water systems are, there is no guarantee that it won't come back to haunt you later and that is what has happened in Minnesota.

(Tardiff) "I have a letter here from Penwalt Corporation dated 1971, in response to a letter I wrote them. They will buy arsenic trioxide in their Briant, Texas plant for 4¢/lb. Some of you gentlemen may have arsenic trioxide which was the arsenic used in North Dakota for grasshopper poisoning in the 1930's.

THE ECOLOGICAL CONSEQUENCES OF MASSIVE QUANTITIES
OF 2,4-D and 2,4,5-T HERBICIDES
SUMMARY OF A FIVE YEAR FIELD STUDY*

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In support of programs testing aerial dissemination systems, a one square mile test grid on Test Area C-52A, Eglin AFB Reservation, Florida received massive quantities of military herbicides. The purpose of these test programs was to evaluate the capabilities of the equipment systems, not the biological effectiveness of the various herbicides. Hence, it was only after repetitive applications that test personnel began to express concern over the potential ecological and environmental hazards that might be associated with continuance of the Test Program. This concern led to the establishment of a research program in the fall of 1967 to measure the ecological effects produced by the various herbicides on the plant and animal communities of Test Area C-52A. This report documents six years of research (1967 - 1973) on Test Area C-52A and the immediately adjacent streams and forested areas.

This report attempts to answer the major questions concerned with the ecological consequences of applying massive quantities of herbicides (345,117 pounds), via repetitive applications, over a period of eight years, 1962 - 1970, to an area of approximately one square mile. Moreover, the report documents the persistence, degradation, and/or disappearance of the herbicides from the Test Area's soils and drainage waters and their subsequent effects (direct or indirect) upon the vegetative, faunal, and microbial communities.

The active ingredients of the four military herbicides (Orange, Purple, White, and Blue) sprayed on Test Area C-52A were 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 4-amino-3,5,6-trichloropicolinic acid (picloram), and dimethylarsinic acid (cacodylic acid). It is probable that the 2,4,5-T herbicide contained the highly teratogenic (fetus deforming) contaminant 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Ninety-two acres of the test grid received 1,894 pounds 2,4-D, 2,4,5-T per acre in 1962 to 1964, while another 92 acres received 1,168 pounds per acre in 1964 to 1966. In the period from 1966 to 1970, a third distinct area of over 240 acres received 343 pounds per acre of 2,4-D and 2,4,5-T, 6 pounds per acre picloram, and in 1969 to 1970, 53 pounds per acre cacodylic acid (28 pounds per acre of arsenic as the organic pentavalent form; calculated on weight of Blue applied per acre).

From the rates of herbicides that were applied during the years of testing spray equipment, it was obvious that Test Area C-52A offered a unique opportunity to study herbicide persistence and soil leaching. Yet the problem of how best to assess the level of herbicide residue was

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a difficult one. The herbicides could be chemically present but because of soil binding might not be biologically active. Thus, both bioassay techniques and analytical analyses were employed. The first major bioassay experiment was conducted in April 1970. By considering the flightpaths, the water sources, and the terracing effects, it was possible to divide the one-square mile test grid into 16 vegetation areas. These areas formed the basis for the random selection of 48 3-foot soil cores. Soybean bioassays indicated that 27 of the 48 cores were significantly different from control cores (95% probability level). The results indicated that soil leaching or penetration was much more prevalent along the dissemination flight paths than in other areas of the test grid. Efforts to quantitate (chemically) the bioassay were confined to only the top 6-inch increment because of within-core variations. By considering that all phytotoxic effects were from Orange (2,4-D and 2,4,5-T) the average value for the top 6 inches of soil core for the eight cores showing greatest herbicide concentration was 2.82 ppm (parts per million) herbicide. Chemical analyses of soil cores collected from the eight sites showing greatest phytotoxic concentrations were performed in December 1970. Results indicated that the maximum concentration of either 2,4-D or 2,4,5-T was 8.7 ppb (parts per billion). A 1970 analysis of soil cores for arsenic, from areas receiving greatest quantities of Blue, indicated maximum levels of 4.70, 1.30, and 0.90 ppm arsenic for the first three 6-inch increments of the soil profile, respectively. These same increments were again collected and analyzed in 1973: levels of arsenic were 0.85, 0.47, and 0.59 ppm for the three consecutive 6-inch increments. Leaching of the arsenical from the soils may have occurred. Picloram analysis in November 1969 of soil cores from areas receiving greatest quantities of White indicated that maximum levels of 2.8 ppm picloram were present in the 6 to 12-inch depth increment. Analysis of the same sites performed in 1971 indicated the picloram had leached further into the soil profile but concentrations were significantly less (ppb). Analysis of soil cores in 1971 showed no residue of TCDD at a minimum detection limit of less than 1 ppb, even in soil previously treated with 947 pounds 2,4,5-T per acre. However, data from soil analysis (via mass spectrometry) of four total samples collected in June and October 1973 indicated TCDD levels of <10, 11, 30, and 710 parts per trillion (ppt), respectively. These levels were found in the top six inches of soil core. The greatest concentration (710 ppt) was found in a sample from the area that received 947 pounds 2,4,5-T in the 1962 - 1964 test period.

A comparison of vegetative coverage and occurrence of plant species on the one-square mile grid between June 1971 and June 1973 has indicated that areas with 0 to 60% vegetative cover in 1971 had a coverage of 15 to 85% in June 1973. Those areas having 0 to 5% coverage in 1971 (areas adjacent to or under flightpaths used during herbicide-equipment testing) had 15 to 54% coverage. The rate of change in coverage seemed to be dependent upon soil type, soil moisture, and wind. There was no evidence to indicate that the existing vegetative coverage was in any way related to herbicide residue in the soil: dicotyledonous or broadleaf plants that are

normally susceptible to damage from herbicide residues occurred throughout the entire one square mile grid. The square-foot transect method of determining vegetative cover indicated that the most dominant plants on the test area were the grasses, switchgrass (Panicum virgatum), woolly panicum (Panicum lanuginosum), and the broadleaf plants rough buttonweed (Diodia teres), poverty weed (Hypericum gentianoides), and common polypremum (polypremum procumbens). In 1971, 74 dicotyledonous species were collected on the one square mile grid; in 1973, 107 dicotyledonous species were found. All of the plant species collected were pressed, mounted, and placed in the Eglin AFB Herbarium.

An evaluation of the effects of the spray-equipment testing program on faunal communities was conducted from May 1970 to August 1973. The extent of any faunal ecological alterations was measured by assessing data on species variation, distribution patterns, habitat preference and its relationships to vegetative coverage, occurrence and incidence of developmental defects, as well as gross and histologic lesions in post mortem pathological examinations.

A total of 73 species of vertebrate animals (mammals, birds, reptiles, and amphibians) were observed on Test Area C-52A and in the surrounding area. Of these 73 species, 22 species were observed only off the grid, 11 species were observed only on the grid, and 40 species were observed to be common to both areas. During the early studies no attempts were made to quantitate animal populations in the areas surrounding the grid; however, in 1970, preliminary population studies by trap-retrap methods were performed on the beach mouse (Peromyscus polionotus) population for a 60 day period to confirm the hypothesis that it was the most prevalent species on the grid. The hypothesis was supported by the capture of 36 beach mice from widely distributed areas on the grid, except in areas with less than 5% vegetation. Eight pairs of eastern harvest mice were taken to the laboratory and allowed to breed. Six of the eight pairs had litters totalling 24 mice. These progeny were free from any gross external birth defects. During February - May 1971 population densities of the beach mouse were studied at eight different locations on the grid along with two different areas off the grid which served as controls. Populations were estimated on the basis of trap-retrap data. There was no difference in mouse population densities in herbicide treated and control areas affording comparable habitats. All indications were that any population differences in other animal species between the test area and the surrounding area were due to differences caused by the elimination of certain plants and, therefore, certain ecological niches, rather than being due to any direct detrimental effect of the herbicides on the animal population present on TA C-52A.

During the last day of the 1971 study, 9 mice were captured and taken to the laboratory for post mortem pathological examination. There were no instances of cleft palate or other deformities. Histologically, liver, kidney and gonadal tissues from these animals appeared normal. In the 1973 study several different species of animals were caught, both on and

off the test grid. These included beach mice, (Peromyscus polionotus), cotton mice, (Peromyscus gossypinus), eastern harvest mice, (Reithrodontomys humulis), hispid cotton rats, (Signodon hispidus), six-lined race-runners, (Cnemidophorus sexlineatus), a toad, (Bufo americanus), and a cottonmouth water moccasin, (Ancistrodon piscivorus). A total of 89 animals were submitted to The Armed Forces Institute of Pathology, Washington, D.C. for complete pathological examination including gross and microscopic studies. Liver and fat tissue from 70 rodents were forwarded to the Interpretive Analytical Services, Dow Chemical U.S.A., for TCDD analyses. The sex distribution of the trapped animals was relatively equal. The ages of the animals varied, but adults predominated in the sample. No gross or histological developmental defects were seen in any of the animals. Several of the rats and mice from both groups were pregnant at the time of autopsy. The stage of gestation varied considerably from early pregnancy to near term. The embryos and fetuses were examined grossly and microscopically, but no developmental defects or other lesions were observed. Gross necropsy lesions were relatively infrequent and consisted primarily of lung congestion in those animals that had died from heat exhaustion prior to being brought to the laboratory. The organ weights did not vary significantly between the test and control animals when an animal with lungs and kidneys showing inflammatory pathological lesions was removed from the sample. Histologically, the tissues of 13 of the 26 control animals and 40 of the 63 animals from the test grid, were considered normal. Microscopic lesions were noted in some animals from both groups. For the most part, these were minor changes of a type one expects to find in any animal population. One of the most common findings was parasites. A total of 11 controls and 9 grid animals were affected with one or more classes of parasites. Parasites may be observed in any wild species and those in this population were for the most part incidental findings that were apparently not harmful to the animals. There were exceptions however. Protozoan organisms had produced focal myositis in one rat, and were also responsible for hypertrophy of the bile duct epithelium in a six-lined racerunner.

Moderate to severe pulmonary congestion and edema were seen in several rats and mice. All of these animals were found dead in the traps before reaching the laboratory, and the lung lesions were probably the results of heat exhaustion. The remainder of the lesions in both groups consisted principally of inflammatory cell infiltrates of various organs and tissues. They were usually mild in extent and although the etiology was not readily apparent, the cause was not interpreted as toxic. The analyses of TCDD from the rodents collected in June and October 1973 indicated that TCDD or a compound chemically similar to TCDD accumulated in the liver and fat of rodents collected from an area receiving massive quantities of 2,4,5-T. However, based on the pathological studies there was no evidence that the herbicides and/or contaminants produced any developmental defects or other specific lesions in the animals sampled or in the progeny of those that were pregnant. The lesions found were interpreted to be of a naturally occurring type and were not considered related to any specific chemical toxicity.

In 1970 beach mice were not found on the more barren sections of the grid (0-5% vegetative cover). There were, however, some areas of the grid which had population densities exceeding those of the species preferred habitat as reported in the literature. In an attempt to correlate distribution of the beach mouse with vegetative cover (i.e., habitat preference) a trapping-retrapping program of 8 days duration was conducted in 1973. The majority of animals (63) were found in areas with 5% to 60% vegetative cover: Within this range, the greatest number of animals trapped (28) was from an area with 40% to 60% cover. A similar habitat preference has been observed along the beaches of the Gulf Coast. In this study, it appeared that the beach mouse used the seeds of switchgrass (Panicum virgatum) and wooly panicum (Panicum lanuginosum) as a food source.

Trapping data from 1971 was compared to trapping data collected in 1973 to determine whether an increase in the population of beach mice had occurred. The statistical evidence derived from that study showed that the 1.64 beach mice per acre population (based on the Lincoln Index for 1973) was slightly higher than the 0.8 and 1.4 mice per acre reported for a similar habitat. The population of beach mice was also higher in 1973 than in 1971 in the area of the test grid. The apparent increase in beach mouse population on the grid in 1973 over 1971 was probably due to the natural recovery phenomenon of a previously disturbed area (i.e., ecological succession). Some areas of the test grid have currently exceeded that preferred percentage of vegetative coverage of the beach mouse habitat, and other areas were either ideal or fast developing into an ideal habitat. If the test grid remains undisturbed and continues toward the climax species, a reduction in the number of beach mice will probably occur simply due to decline of preferred habitat.

A 1973 sweep net survey of the Arthropods of Test Area C-52A resulted in the collection of over 1,700 specimens belonging to 66 insect families and Arachnid orders. These totals represented only one of five paired sweeps taken over a one-mile section of the test grid. A similar study performed in 1971 produced 1,803 specimens and 74 families from five paired sweeps of the same area using the same basic sampling techniques. A much greater number of small to minute insects were taken in the 1973 survey. Vegetative coverage of the test area had increased since 1971. The two studies showed similarities in pattern of distribution of Arthropods in relation to the vegetation, number of Arthropod species, and Arthropod diversity. Generally, the 1973 study showed a reduction of the extremes found in the above parameters in the 1971 study. This trend was expected to continue as the test area stabilizes and develops further plant cover, thus allowing a succession of insect populations to invade the recovering habitat.

There are two classes of aquatic areas associated with the Test Area; ponds actually on the square mile area and streams which drain the area. Most of the ponds are primarily of the "wet weather" type, drying up once in the last five years, although one of the ponds is spring fed. Three major streams and two minor streams drain the test area. The combined

annual flow of the five streams exceeds 24 billion gallons of water. Seventeen different species of fishes have been collected from the major streams while three species have been collected from the spring-fed pond on the grid. Statistical comparisons of 1969 and 1973 data of fish populations in the three major streams confirm a chronologically higher diversity in fish populations. However, the two control streams confirm a similar trend in diversity. Nevertheless, from examining all of the aquatic data, certain observations support the idea that a "recovery" phenomenon is occurring in the streams draining TA C-52A. These observations are difficult to document because of insufficient data. For example, in 1969, the Southern Brook Lamprey (Ichthyomyzon gagei) was never collected in one of the streams immediately adjacent to the area of the grid receiving the heaviest applications of herbicides; however, in 1973 it was taken in relatively large numbers. These observations may or may not reflect a change in habitat due to recovery from herbicide exposure. Residue analyses (1969 to 1971) of 558 water samples, 68 silt samples and 73 oyster samples from aquatic communities associated with drainage of water from Test Area C-52A showed negligible arsenic levels. However, a maximum concentration of 11 ppb picloram was detected in one of the streams in June 1971 but dropped to less than 1 ppb when sampled in December 1971. TCDD analysis of biological organisms from streams draining Test Area C-52A or in the ponds on the test area were free from contamination at a detection limit of less than 10 parts per trillion.

In analyses performed 3 years after the last application of 2,4-D and 2,4,5-T herbicide the test grid exhibited population levels of soil microorganisms identical to that in adjacent control areas of similar soil and vegetative characteristics not exposed to herbicides. There were increases in Actinomycete and bacterial populations in some test site areas over levels recorded in 1970. This was possibly due to a general increase in vegetative cover for those sampling sites and for the entire test grid. No significant permanent effects could be attributed to exposure to herbicides.

Data on aquatic algal populations from ponds on the one square mile grid (previously exposed to repetitive applications of herbicides) indicated that the genera present were those expected in warm, acid (pH 5.5), seepage, or standing waters.

FIELD STUDIES ON THE SOIL PERSISTENCE AND MOVEMENT OF 2,4-D, 2,4,5-T, and TCDD*

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INTRODUCTION

Concern over the level of contamination of 2,4,5-trichlorophenoxy-acetic acid (2,4,5-T) herbicide by the teratogen 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) may result in the disposal of selected inventories of this herbicide. A potential disposal method is that of soil incorporation. The soil incorporation method is based on the premise that high concentrations of phenoxy herbicide and TCDD will be degraded to innocuous products by the combined action of soil microorganisms and soil chemical hydrolysis.

It has been known for several years that the rate at which herbicides disappear from the soil is largely dependent upon their susceptibility to metabolism by soil microorganisms. Much of the information available on the biological breakdown of the phenoxy herbicides comes from laboratory studies and is very useful for predicting what might happen when relatively high concentrations of phenoxy herbicides are applied to a soil incorporation site. Conversely, a certain amount of caution must always be used when extrapolating laboratory data to a field situation. Data on the field persistence of TCDD is extremely limited primarily due to the low levels of contamination in commercial formulations, the rate of application of such formulation, and the lack of a sensitive analytical method for the detection of TCDD. This report documents current field research on the soil degradation of a TCDD-contaminated phenoxy formulation when incorporated in the soil at massive rates of application.

METHODS AND MATERIALS

In August 1972, a site for the soil incorporation of phenoxy herbicides was selected on the Air Force Logistics Command Test Range Complex, Hill Air Force Base, Utah. The potential site was characterized as being relatively flat and having a uniform surface without rock outcrops or areas of marked deflation or dunes. Sediments in this area are lacustrine in origin and were deposited when ancient Lake Bonneville covered this region of the Great Basin. Sediments consist of clays interlaced irregularly with sand lenses and remnant stream sands; the clays predominating. The undifferentiated clays contain various amounts of dissolved salts. Table 1 shows an analysis of the top two

*Presentation to the Weed Science Society of America, 13 February 1974, Las Vegas, Nevada. Abstract No. 226.

TABLE 1. Soil analysis of the top two six-inch soil increments from the soil incorporated plots, Air Force Logistics Command Test Range Complex, Hill Air Force Base, Utah^a

Inches	pH	Organic Carbon (%)	Electrical Conductivity (EC x 10 ³) ^b	Ca/Mg meq/100g soil)	K	Na	Sand (%)	Silt (%)	Clay (%)	Moisture at Saturation (%)
0-6	7.8	0.82	28.0	23.7	3.9	13.4	27	53	20	31.1
6-12	7.9	0.95	31.0	23.8	3.9	13.2	26	52	22	34.2

^a Determined by Soils Laboratory, Utah State University, Logan, Utah, and the Soils Laboratory, Kansas Agricultural Experiment Station, Garden City, Kansas.

^b Electrical conductivity in millimhos per cm at 25 C.

six-inch increments (0-6, 6-12 inches) of the soil profile. The annual rainfall of the area is less than ten inches taking into consideration the water equivalent of snowfall. Ground water of the area varies from 16 to 20 feet below the surface. It is supplied primarily by the precipitation falling on the nearby mountains. The small amount of water which percolates through the existing clays moves laterally westward towards the salt flats, picking up chemical matter from these clays. As a result, the ground water contains up to 1,000 parts per million (ppm) sodium chloride. The annual mean daily minimum temperature is 38.5 F and the annual mean daily maximum temperature is 64.7 F. The experimental area has a vegetative cover of 15 percent and is dominated by fourwing saltbush, *Atriplex canescens* (Pursh) Nutt.; halogeton, *Halogeton glomeratus* (M. Bieb.) C.A. Mey; and graymolly, *Kochia vestita*.

Six field plots, each 10 x 15 feet, were established on the Air Force Logistics Command Test Range Complex on 6 October 1972. To simulate subsurface injection (incorporation), three equally-spaced trenches, 6 inches wide and 10 feet in length were dug to a depth of 4-6 inches in each plot. The rates of herbicide selected for incorporation were 1,000, 2,000, and 4,000 pounds active ingredient per acre (lb ai/A) 2,4-D plus 2,4,5-T. Two replications (plots) per rate were included in the experiment. The quantity of herbicide required for each rate was divided into three equal parts and sprayed, as the concentrate, into each of the three trenches per plot, respectively. A hand sprayer with the nozzle removed was used to spray as uniformly as possible an approximate two-to-three-inch band of herbicide in the center of the 6-inch by 10-foot trench. The trenches in each plot were then covered by use of a handshovel, tamped, and levelled using a handrake.

The herbicide formulation used for these simulated incorporation experiments was an approximate 50:50 mixture of the n-butyl esters of 2,4-D and 2,4,5-T. One gallon of this formulation contains 4.21 pounds of the active ingredient of 2,4-D and 4.41 pounds of the active ingredient of 2,4,5-T. The formulation was originally specified to contain:

n-butyl ester of 2,4-D	49.40%
free acid of 2,4-D	0.13%
n-butyl ester of 2,4,5-T	48.75%
free acid of 2,4,5-T	1.00%
inert ingredients (e.g., butyl alcohol and ester moieties)	0.62%

Some of the physical, chemical, and toxicological properties of the herbicide formulation are:

Specific Density (25 C)	1.282
Viscosity, centipoise (23 C)	43
Molecular mass	618
Weight of Formulation (lbs/gal)	8.63
Soluble in water	no
Specific toxicity for female white rats (mg formulation/ kg body weight)	566

A 200 ml sample of the formulation was removed from the container of herbicide used on these plots, placed in a hexane-acetone-rinsed glass jar and shipped to the Interpretive Analytical Services Laboratory, Dow Chemical U.S.A., Midland, Michigan, for analysis of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The results of the analysis indicated a concentration of 3.7 parts per million (ppm) TCDD.

The first initial soil samples were to be taken the following day after incorporation of the herbicide. However, because of adverse weather initial samples were not obtained. Beginning in January 1973 soil samples were collected routinely every 2-3 months. Sampling was done by using a 3-inch by 6-inch hand auger. Each row (trench) in each plot was sampled once by removing 6-inch increments to a depth of 36 inches. Each depth was uniformly mixed per plot (i.e., the three rows per plot were mixed for each depth), placed in sample containers, and shipped under dry ice to the laboratory for herbicide analysis. In all cases, the soil cores were obtained as accurately as possible from the center of the 6-inch wide row (trench). In the laboratory, each sample was analyzed for 2,4-D acid, 2,4,5-T acid, 2,4-D n-butyl ester, and 2,4,5-T n-butyl ester by the gas chromatographic procedure of Arnold and Young (in press, Analytical Chemistry, 1974).

RESULTS AND DISCUSSION

The results of the analysis of soil samples taken from the test plots are displayed in Tables 2-4. Table 2 illustrates the loss of total active herbicide from the upper 12 inches of soil increment over a period of 440 days (6 Oct 1972 - 14 Dec 1973). Assuming normal climatological conditions this period represents 7 months of relatively cold temperatures and 7 months of relative warmth. The percent loss of herbicide over just the 330 day sampling period (from 110 to 440 days) was 78.2%, 75.2% and 60.8% for the 1,000, 2,000, and 4,000 lb ai/A plots, respectively. If the theoretical values for herbicide concentration at day 0 are used, percent loss of herbicide during the entire experiment was 87.8%, 85.3% and 82.6%, respectively. These data tend to indicate a decreased degradation of herbicide with increased application rate. However, the unusually low rate calculated for 4,000 lb ai/A application over the 330-day period is likely a result of low value of herbicide measured in the first sample (110 days) rather than a difference in degradation rate. If a strict exponential decay curve is assumed, the half life for the total herbicide ranges from 146 to 155 days depending on application rate.

Tables 3 and 4 illustrate the individual loss of each of the herbicides (2,4-D and 2,4,5-T) contained in the original formulation. Except at the lowest rate of application, no significant difference was seen in the rate of degradation of the individual components in this formulation. At the application rate of 1000 lbs/A, there was a 7.5% difference (rate, 2,4-D = 81.2%; 2,4,5-T = 73.7%) in degradation rates. It was originally thought that this was due to laboratory error, however, further sampling has tended to confirm this difference. It should be noted at this

TABLE 2. Soil concentration, part per million, of 2,4-D and 2,4,5-T herbicide at selected sampling periods, days, following soil incorporation.

Application Rate of Formulation (lb ai/A) ^b	Sampling Time After Incorporation (Days) ^a				
	0 ^c	110	220	282	440
1,000	10,000	5,580	1,876	----	1,216
2,000	20,000	11,877	----	4,670	2,944
4,000	40,000	17,729	----	8,489	6,944

^a Data represent an average of two replications with the duplicate samples of each replication: the total value for depths 0-6 and 6-12 inches of soil increment.

^b Pounds active ingredient per acre.

^c Theoretical concentration at time of application based on a two-inch spray swath at a depth of 4-6 inches within the soil profile.

TABLE 3. Soil concentration, parts per million, of 2,4-D herbicide at selected sampling periods, days, following soil incorporation.

Approximate ^a rate of 2,4-D (lb ai/A)	Sampling Time After Incorporation (Days) ^b				
	0 ^c	110	220	282	440
500	5,000	3,280	976	----	616
1,000	10,000	7,261	----	2,370	1,844
2,000	20,000	10,545	4,829	----	4,112

^a Rate of herbicide per acre was based on the original specification of the formulation (i.e., a 50:50 n-butyl formulation containing 8.63 pounds active ingredient per gallon).

^b Data represent an average of two replications with two duplicate samples of each replication: the total for depths 0-6 and 6-12 inches of soil increment.

^c Theoretical concentration at time of application based on two-inch spray swath at a depth of 4-6 inches within the soil profile.

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2,000	20,000	10,545	4,829	----	4,112

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^b Data represent an average of two replications with two duplicate samples of each replication: the total for depths 0-6 and 6-12 inches of soil increment.

^c Theoretical concentration at time of application based on two-inch spray swath at a depth of 4-6 inches within the soil profile.

TABLE 4. Soil concentration, parts per million, of 2,4,5-T herbicide at selected sampling periods, days, following soil incorporation.

Approximate ^a Rate of 2,4,5-T (lb ai/A)	Sampling Time After Incorporation (Days) ^b				
	0 ^c	110	220	282	440
500	5,000	2,300	900	----	604
1,000	10,000	4,616	----	2,300	1,100
2,000	20,000	7,184	----	3,734	2,832

^a Rate of herbicide per acre was based on the original specification of the formulation (i.e., a 50:50 n-butyl formulation containing 8.63 pounds active ingredient per gallon).

^b Data represent an average of two replications with two duplicate samples of each replication: the total for depths 0-6 and 6-12 inches of soil increment.

^c Theoretical concentration at time of application based on two-inch spray swath at a depth of 4-6 inches within the soil profile.

point that while it was originally assumed that the formulation which was applied contained equal amounts of each herbicide, data obtained from soil analysis tended to contradict this assumption. On the first sampling date the soils contained an average of 66.9% 2,4-D and only 33.1% 2,4,5-T. This ratio was approximately maintained throughout the study. A sample of the herbicide formulation was analyzed by gas chromatographic-mass spectrometry techniques and found to contain approximately 60% 2,4-D and 40% 2,4,5-T. In addition to the butyl esters, the formulation also contained relatively large amounts of octyl and iso-octyl esters of both components.

A great deal of difficulty was encountered in our attempt to accurately measure the rate of herbicide loss in these field samples. Without averaging, loss rates calculated varied over a rather large range from sample to sample. Even with averaging a few samples which were analyzed were not included in the data due to extreme variations in herbicide concentration, i.e. much higher or lower than previous samples. We attribute these variations to a number of uncontrollable variables, the most significant of which was a variation in application rates within the test rows. When the test plots were established, the herbicide was sprayed into the rows with a hand sprayer and it appears likely that there were originally concentration differences at various points due to this method of application. A second source of error is attributable to the moisture content of the soil samples. On some of the sampling dates, the samples received were extremely wet due to snow drifts over the plots while others were relatively dry. This variation in moisture tended to change the consistency of the soil and in many cases made the obtaining of a uniform sample impossible. A third source of variation occurred due to the composition of the herbicide sample which was originally applied. As was previously mentioned in addition to the expected n-butyl esters of 2,4-D and 2,4,5-T, a portion of the formulation of the sample was made up of n-octyl and iso-octyl esters of the two herbicides. No attempt was made to analyze for these esters in the soil samples; consequently, the effect of these compounds on the overall degradation pattern would only be noted after they had been hydrolyzed to the free acid. Since the rates of hydrolysis of these compounds may be different than that of n-butyl esters, this is another possible source of variation in the data obtained on early sampling dates.

In order to minimize variations in the data, on February 1, 1973, small amounts of soil (200 g) from the field plots were analyzed and placed in glass stoppered bottles. These bottles were then placed in a constant temperature incubator at 83 F to be analyzed periodically at later dates. The analytical data from these samples are presented in Table 5. Average percent loss/day values calculated from these samples were 0.42%/day for 2,4-D and 0.48%/day for 2,4,5-T. Half lives for 2,4-D and 2,4,5-T calculated from these data are 119 days and 104 days, respectively. In these samples it appears that the rate of degradation decreases with time since, in most samples, the loss of herbicide was greater from day 0 to 82 than between days 82-156. Apparently initial concentration had little effect on the degradation rate. The average rates of loss for the 6 samples with the highest initial concentrations were .43 and .48 while those for the 6

TABLE 5. Loss of herbicide (ppm) from field samples incubated in the laboratory at 83 F.

Sample Number	0 Days		82 Days		156 Days		Total loss/day (percent)	
	2,4-D ^a	2,4,5-T ^b	2,4-D	2,4,5-T	2,4-D	2,4,5-T	2,4-D	2,4,5-T
1	2740	1980	2300	1178	868	480	.44	.44
2	2440	1500	1412	695	680	320	.46	.50
3	3220	2380	1340	820	840	488	.47	.51
4	2360	1500	1260	750	784	440	.43	.45
5	5704	4220	3148	1640	2000	1124	.42	.47
6	5484	3388	2408	1350	1852	920	.43	.47
7	3260	2100	1540	760	1164	632	.41	.45
8	2980	2200	1162	547	1300	720	.36	.43
9	9680	7080	4584	2408	3552	1740	.41	.48
10	11000	7720	4644	2388	3590	1902	.43	.48
11	2820	1820	1500	700	1032	608	.41	.43
12	3320	2440	1448	895	1028	500	.44	.51
AVG.	4584	3194	2229	1178	1558	823	.42	.43
TOTAL	55,008	38,328	26,746	14,131	18,690	9,879		

^a Total value for esters and acids of 2,4-D.

^b Total value for esters and acids of 2,4,5-T.

samples of lowest concentration were .42 and .46, respectively, and are therefore not significantly different.

One observation that was apparent in all degradation studies which have been performed is the relatively rapid hydrolysis of the n-butyl esters of the herbicide due to contact with the alkaline Utah soils. Table 6 gives the percentage saponification of the n-butyl esters of 2,4-D and 2,4,5-T to the acids over a period of 282 days for two different application rates. It was found that in all samples, the rate of hydrolysis of n-butyl 2,4-D was greater than that of n-butyl 2,4,5-T. Moreover, it is likely that at the higher concentrations (e.g., 4,000 lb ai/A), the acid salts formed could not be removed at a sufficiently rapid rate (via degradation and/or penetration), causing the chemical equilibrium to shift to the left.

Data concerning herbicide penetration in Utah soils are shown in Table 7. Samples from lower soil increments were taken from those plots where it was expected that herbicide concentrations would be most likely to penetrate into the soils. With one exception, both 2,4-D and 2,4,5-T residues were found at all levels sampled. In all cases the total herbicide concentration in levels greater than 18 inches was made up entirely of the free acids. Butyl esters were not detected at depths greater than 12 inches for 2,4-D or 18 inches for 2,4,5-T. It is also interesting to note that the penetration of 2,4-D is greater than that of 2,4,5-T. Apparently this is due to the greater water solubility of the free acid of 2,4-D. This may also explain why 2,4-D appeared to degrade more slowly in laboratory samples where there was no loss from the sample due to penetration.

In June 1973, a composite soil core from one of the 4,000 lb ai/A plots was selected for TCDD analysis. The Interpretive Analytical Services Laboratory, Dow Chemical U.S.A. performed the analysis using a modification of the method developed by Baughman and Meselson (published in Environmental Health Perspectives, Experimental Issue No. 5, September 1973). The following data were obtained:

Sample	2,3,7,8-tetrachlorodibenzo-p-dioxin	
	parts per trillion	parts per billion
Control (0-6 inches)	<10	<10
Plot 5 (0-6 inches)	15,000	15.00
Plot 5 (6-12 inches)	3,000	3.00
Plot 5 (12-18 inches)	90	0.09
Plot 5 (18-24 inches)	120	0.12

Thus, within the four samples from the plot 5 core (4,000 lb ai/A) a total concentration of 18,210 ppt (18.21 parts per billion - ppb) was found. Undoubtedly the lower two depths (12-18 and 18-24 inches) represent contamination from the upper two increments, via the use of the hand auger.

TABLE 6. Percentage saponification of the n-butyl esters of 2,4-D and 2,4,5-T at selected time periods, days, following soil incorporation in alkaline soils.

Application Rate of Formulation	Days After Incorporation ^a			
	0	110	220	282
1,000 lb ai/A ^b				
Esters	100	24	13	3
Acids	0	76	87	97
4,000 lb ai/A				
Esters	100	77	40	32
Acid	0	23	60	68

^a Data are the percent acid and esters of herbicides found in top 0-6 of soil profile.

^b lb ai/A = pounds active ingredient per acre.

TABLE 7. Herbicide (2,4-D and 2,4,5-T) penetration (ppm) in the 4,000 lb ai/A plots 282 days after soil incorporation.

Depth (inches)	2,4-D ^a (ppm)	2,4,5-T ^a (ppm)	Percent of total Herbicide
0-6	4262	2982	72.4
6-12	1093	752	18.4
12-18	126	101	2.3
18-24	158	70	2.7
25-30	230	50	2.9
30-36	161	21	1.8

^a Data are an average of two analyses and represents the total of both the ester and acid components.

Since the TCDD concentration of the formulation was known (see Methods), and since its determination in the soil core was performed by the same laboratory and instrumentation, an estimation of the degradation of TCDD can be obtained by comparison to the expected value based on the known concentration of herbicide at time of sampling. Subsamples of the soil core analyzed for TCDD were also analyzed for 2,4-D and 2,4,5-T. The total concentration of herbicide in the 0-6 and 6-12 inch increments was approximately 14,000 ppm. Therefore, the actual concentration should have been approximately 51.8 ppb TCDD ($14,000 \times 3.7 \times 10^{-3} = 51.8$) if degradation of the TCDD was at the same rate as 2,4-D and 2,4,5-T. If the theoretical values for herbicide concentration at day 0 (time of incorporation) are used, then the initial concentration of TCDD would have been 148 ppb ($40,000 \times 3.7 \times 10^{-3} = 148$ ppb). The percent loss of TCDD over a period of 265 days was 87.7% ($18.21/148 = 12.3\%$; $100\% - 12.3\% = 87.7\%$). The value 87.7% would represent 3 half-lives for TCDD persistence. Therefore a rough estimate for the half-life of TCDD would be 88 days in these alkaline soils, under desert conditions, and in the presence of massive quantities of 2,4-D and 2,4,5-T.

These preliminary data suggest that TCDD degrades at a more rapid rate than 2,4-D or 2,4,5-T. Moreover, the movement of the TCDD to the 6-12 inch depth probably represents co-movement with the massive amounts of esterified herbicide, rather than independent penetration into the soil profile.

COMMENTS ON WORK GROUP RECOMMENDATIONS

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department of microbiology

May 18, 1973

Mr. David A. Wagoner
Director
Categorical Programs Division
United States Environmental
Protection Agency
1860 Lincoln Street
Denver, Colorado 80203

Dear Mr. Wagoner:

I have reviewed the recommendations of the two work groups attending the Pesticide Container Disposal Conference, and have the following comments.

The state legislation and regulations guidelines are a good start, but lack the thoroughness that is necessary if this problem is to be solved. Solutions to the safe disposal of pesticides wastes and containers based on current technology will probably follow procedures currently developed and in use in solid wastes programs. These will have to include farm-ranch premises storage, transport to centrally located transfer stations and to a final disposal or container refurbishing site. Most states in region six will be fortunate if they can maintain a few areas in a state for hazardous materials disposal. These sites should pass scrupulous inspection, have hydrologic, geologic, and detailed engineering studies done prior to use. Operators at the disposal sites should undergo rigorous training, the sites and operators should also be monitored for pesticides during the operating season. All disposal sites should be recorded at the county clerks office and a detailed list of materials disposed in the site should be maintained for inspection of the enforcing agency.

Concurrently a great deal of effort should be put forth by the Environmental Protection Agency to improve packaging and containerization of hazardous materials.

I think you will have to also face the problem that the disposal of pesticide wastes and containers will be expensive, and frankly I don't see how some sparsely settled states can afford it. Revolving funds might work, but their use has some inherent problems. If you recall the experience in Montana recently-I believe the cost of disposal of materials in one episode was over two thousand dollars.

I think your idea of establishing a state/federal hazardous waste committee is good, but would suggest that you place a limited number of consumers on the committee.



Mr. David A. Wagoner

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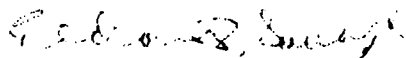
May 18, 1973

I would not overlook the possibility of using some of the extension people at the State Agricultural Schools in trying to carry out the mission. There is an excellent state wide network available and I am sure you would receive excellent cooperation from them in all states in the region.

Lastly, as you well know new methods of pesticides wastes disposal must be found. I think the time is ripe for renewed interest and funding in this area. The research should be removed out of the laboratory to the applied problem at hand. If this is done vigorously we should have improved answers to this most important problem in the immediate future.

Your group is to be congratulated on coming to grips with the pesticides waste disposal problem.

Sincerely,



Eldon P. Savage, Ph.D.
Chief, Chemical Epidemiology Section
Institute of Rural Environmental Health

EPS/50