

U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH RELATED TO POLLUTION CONTROL TECHNOLOGY
FOR MATERIALS THAT EXHIBIT CHEMICAL TOXICITY

An Evaluation of Recent, Current, and Planned Efforts



April 10, 1980

Science Advisory Board
U.S. Environmental Protection Agency

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This report has been written as a part of the activities of the Agency's Science Advisory Board, a public advisory group providing extramural scientific information to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency, and hence its contents do not necessarily represent the views and policies of the Environmental Protection Agency.

FOREWORD

This report is an evaluation of the recent, current, and planned efforts in EPA on research related to pollution control technology for waste materials that exhibit chemical toxicity. The study was undertaken by the Technology Assessment and Pollution Control Committee (TAPCC) because the Committee perceived that there may be inadequate research and development in this area.

The report was reviewed by the Committee at its open meeting in Washington, D.C. on March 5, 1980. Certain minor corrections and changes were suggested and have been incorporated into the report. The report was subsequently approved by the full Committee.

A synopsis of this report was presented to the Executive Committee of the Science Advisory Board on April 9, 1980 and was received without any significant criticism. However, clarification as to the intent of certain statements was suggested and this clarification has been incorporated into the text.

Respectfully submitted,



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Chairman

Technology Assessment and
Pollution Control Committee
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William N. McCarthy, Jr.
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1.0 EXECUTIVE SUMMARY

This report is a result of a study undertaken by the Technology Assessment and Pollution Control Committee (TAPCC) of the Science Advisory Board, Environmental Protection Agency (EPA), to evaluate the existence and adequacy of research conducted by EPA related to control technology for the management, treatment, and disposal of materials that exhibit chemical toxicity. The study did not evaluate any private sector or industry research and development efforts related to toxics-control technology. This study was conducted during the period March 1979 through November 1979.

In conducting its evaluation, TAPCC did not define "materials that exhibit chemical toxicity" in any narrow, legal interpretation. Rather, TAPCC interest was on toxic chemicals that have the capability to produce illness, abnormalities, or death in man or any organisms or their offspring. Henceforth, in this report these materials will be referred to as "toxics." The Committee considered EPA research related to control of toxics in drinking water, industrial wastes, municipal wastewater, solid wastes, and in the by-products of energy extraction and combustion.

TAPCC did not attempt to rate individual research projects, laboratory programs, or program office activities. Instead, the Committee attempted to determine whether EPA research efforts on this topic were sufficient to provide a sound scientific and technological base for EPA's current and future regulatory actions.

TAPCC interest in this topic was prompted by a perception that many senior individuals in EPA felt that currently available technology was ready for widespread use and was adequate for current and future regulatory needs. This feeling is not shared by TAPCC members.

Based upon its discussions with individuals in various EPA research and program offices and its review of various reports, TAPCC concludes that:

- a) The current EPA research program on control of toxics will not provide the sound technological base to meet future programmatic and regulatory needs of the Agency;
- b) There should be increased research expenditures on control technology for toxics. For example, in the area of hazardous wastes (Table 1), there is a decreasingly small fraction (10.5% in FY '80 and 4.5% in FY '81) of research expenditures planned for control technologies other than incineration and land disposal. Furthermore, incineration is the only technology that is planned to receive a budget increase.
- c) There is little long-term research on control technology for toxics;
- d) Research related to control technology of toxics has not adequately considered the intermedia transfer of toxics. For example, research on the removal of toxics from wastewater normally does not address the concomitant problem of the disposal of the sludge containing the transferred toxics.

Therefore, TAPCC recommends the following:

1. EPA should initiate efforts to identify and develop technologies that can reduce effluent concentrations

of toxics to the parts per billion (ppb) and parts per trillion (ppt) range, so that such control technology will be available when health and ecological studies indicate the need for its application.

2. The EPA research effort on the development of toxics control technology should be parallel with, rather than sequential to, the current EPA research effort on identification of problems relating to toxics.
3. An integrated multi-media approach should be used in the EPA research program for the control of toxics. For example, in assessing control technologies, the physical state of and ultimate sink for the toxics should be considered and assessed. Control technology that merely results in the intermedia transfer of toxics and which does not accomplish or lead to effective ultimate disposal should not receive a high priority for EPA support.
4. Research emphasizing identification and containment or elimination of toxics at their source of production should be expanded to minimize the amounts of toxics introduced into the environment.
5. EPA should broaden its research program to include studies on the role played by micro-particulate matter suspended in aqueous streams. These micro-particles may be toxic or adsorb toxics. These studies should focus on the influence of micro-particles on:
 - a) Transport, fate and toxicity of toxics dissolved in the aqueous streams, and
 - b) the effectiveness of control technology to remove toxics.

6. Attempts to characterize "removability" and "treatability" of toxics should be continued.

2.0 INTRODUCTION

It has been estimated (Blair et al., 1979) that each year, U.S. industry must dispose of more than 35 million tons of hazardous waste generated from diverse production processes. A substantial fraction of these wastes are toxic. These toxic solids, sludges, liquids, and gases may cause death or illness or pose a substantial hazard to humans and the environment if handled or disposed of improperly.

Several pieces of Federal Legislation, for example, the Amendments to the Federal Water Pollution Control Act (FWPCA), the Resource Conservation and Recovery Act (RCRA) and the Toxic Substances Control Act (TSCA), gave EPA the responsibility for controlling toxics. To support EPA's mandate to conduct research related to such control, the Office of Research and Development developed specific program goals. These include a) identification and monitoring of disposal sites, b) characterization of hazardous wastes that are toxic, c) development of toxic control techniques, and d) development of cleanup and disposal technology. Six EPA laboratories have current responsibility for such research. Three are concerned with control technology development (the Industrial Environmental Research Laboratories (IERLs) at Cincinnati, Ohio, and Research Triangle Park, North Carolina; and the Municipal Environmental Research Laboratory (MERL) at Cincinnati). Examples of the types of research undertaken by these laboratories are noted in Appendix A.

The research budget for control of toxics is contained in several EPA media areas, i.e., Water Quality, Drinking Water, Solid and Hazardous Wastes, and Energy. As an example, the

four-year budget for the Solid and Hazardous Wastes Research program is listed in Table 1. A part of this budget is devoted to the control of toxics. The budget shows that dollars allocated to control technology development, other than incineration, have decreased.

Current EPA topics related to toxics-control technology, brought to the attention of TAPCC, are listed in Table 2. The topics are classified into the broad categories of chemical alteration, concentration and separation, and other control studies and technologies.

3.0 OBJECTIVES

This study was undertaken to evaluate the existence and adequacy of research related to control technology for the management, treatment, and disposal of toxics. The study was carried out from March to November 1979.

The Committee's inquiry considered various Agency activities and their relationships to research on technology for controlling toxics.

TAPCC chose to use a broad, generic definition of toxics rather than a narrow legalistic definition. In general, toxics are those materials that exhibit chemical toxicity and have the capability to produce illness, abnormalities or death in man or any organisms and their offspring. The Committee reviewed EPA toxics-control research activities related to drinking water, solid wastes, industrial wastes, municipal wastewater, and by-products of energy extraction and combustion.

Control technology, for the purposes of this study, is defined as the broad use of control devices and management

TABLE 1

RESEARCH BUDGETS FOR SOLID AND HAZARDOUS WASTES PROGRAM
OFFICE OF RESEARCH AND DEVELOPMENT (ORD); EPA

<u>Research Activity</u> ¹	<u>Research Expenditures (\$ Million)</u>			
	<u>FY '78</u> ²	<u>FY '79</u> ²	<u>FY '80</u> ³	<u>FY '81</u> ³
Hazardous Waste Control Technologies				
Incineration Research			2.3	8.2
Land Disposal Research			5.2	4.2
Other Treatment Research			<u>1.5</u>	<u>1.2</u>
	<u>2.4</u>	<u>3.4</u>	9.0	13.6
Quality Assurance & Monitoring			0.5	4.5
Emergency Response/Remedial Action			0.8	3.4
Health Risk Assessment			---	3.0
High Volume/Industrial Waste Characterization			1.8	1.1
Exploratory Research Center			---	0.8
Municipal Waste/Residue Recovery/T&F			2.1	---
	<u>\$6.6</u>	<u>\$7.9</u>	<u>\$14.2</u>	<u>\$26.4</u>

¹ Specific breakdown of research activities applicable only to FY '80 and FY '81.

² L.H. Blair et al., Science and Technical Needs for Hazardous Waste Management October 1979.

³ Communication from Office of Research and Development, January 29, 1980

TABLE 2

EPA RESEARCH TOPICS IN TOXICS-CONTROL TECHNOLOGY*

1. Chemical alteration
 - 1.1 Incineration
 - a) bench scale -- studies on single priority pollutants or synthetic mixtures at the University of Cincinnati
 - b) pilot scale -- pilot scale rotary kiln on site of Cincinnati incinerator
 - c) commercial scale
 - i. Cincinnati boiler
 - ii. cement kiln
2. Concentration and Separation
 - 2.1 Carbon adsorption -- including field, stationary, and mobile units
 - 2.2 Coagulation and flocculation studies
 - 2.3 Ultrafiltration
 - 2.4 Ion exchange
 - 2.5 Solvent extraction
3. Other Control Studies and Technologies
 - 3.1 Liners for leachate containment
 - 3.2 Solvent degreasing
 - 3.3 Spill prevention control and containment
 - 3.4 Aerosol control
 - 3.5 Reclamation of hazardous wastes

*Topics brought to the attention of the Technology Assessment and Pollution Control Committee

practices to prevent unacceptable levels of risk from exposure to toxics in the environment.

Control technology is needed to (a) remove toxics from the environment so that the residual concentration is at or below that equivalent to the acceptable level of risk and (b) isolate and contain, destroy, or treat the removed material to insure that the material is "detoxified" or will not re-enter the environment. The strategies and processes to remove toxics from the environment include (a) end-of-pipe technologies, (b) industrial process changes, including changes in raw materials, and (c) removal of the chemical or material from commerce. Toxics may be intermediates, primary products or by-products of manufacturing and use. Isolation and treatment of removed materials include control of the residues and sludges that result.

The Committee did not rate individual research projects, laboratory programs, or program office activities; this study was not a peer review activity. Rather, TAPCC attempted to ascertain whether EPA's toxics-control technology research would provide a sound scientific and technological base for EPA's current and future regulatory actions. The Committee also wanted to assess whether the research would improve EPA's overall ability, as an Agency a) to respond to legislation requiring control of toxics and b) to provide guidance, instruction, and information on suitable technology to control toxics.

TAPCC interest for this study was prompted by the sense the Committee perceived within the Agency that currently available technology is adequate to meet regulatory needs, that this technology is ready for widespread use, and that all that EPA needs to do is write the regulations based on such technology. TAPCC members questioned this optimism.

4.0 PROCEDURES FOR CARRYING OUT THE PROGRAM EVALUATION

TAPCC evaluated the adequacy of EPA's control technology research program in terms of its ability to accomplish the following:

- a) identify and classify toxics,
- b) evaluate ecological and health effects of toxics,
- c) develop and evaluate the adequacy of toxics control technology, and
- d) set regulations for the control of toxics.

TAPCC held three meetings, one in Research Triangle Park, North Carolina, one in Cincinnati, Ohio, and one in Washington, D.C. At these meetings, TAPCC members heard presentations and received descriptive materials on existing programs, planned activities, and current and future policy thinking with respect to the control of toxics. The specific groups visited were at the MERL in Cincinnati and at the IERLs in Cincinnati and Research Triangle Park. Representatives from the Office of Solid Waste (OSW), the Office of Toxic Substances (OTS), and the Effluent Guidelines Division (EGD) of the Office of Water Programs (Washington, D.C.) met with the Committee and discussed pertinent items of interest. Meetings typically lasted two days with a three-month interval between meetings. These meetings were augmented by telephone discussions and small group writing sessions which culminated in this report.

In addition, TAPCC members reviewed pertinent documents especially the OSTP/ISETAP report on Scientific and Technical Needs for Hazardous Waste Management (Blair et al., 1979) and the Conservation Foundation Report titled, An Issue Report: Determining Unreasonable Risk Under the Toxic Substances Control Act (Davies et al., 1979).

This report provides comments, impressions, and recommendations based upon these investigations.

5.0 EVALUATION OF EPA RESEARCH FOR CONTROL OF TOXICS

The evaluation of EPA's program was accomplished by considering the four topics listed in section 4.0 and is presented in this section.

5.1 Identify and Classify Toxics

Toxic materials must be defined with a minimum number of parameters to describe their emission into, transport in, and interaction with the environment. Information must also be available on the ability to separate toxics from the streams in which they are contained and on the ability to isolate toxics from the environment once they are separated.

TAPCC noted that EPA had research underway on source identification of toxic emissions both in the environment and from industrial manufacturing process, e.g., the organic chemical industry. In addition, EPA is observing decision-making processes for toxic emissions control in other countries. The work in this area appears adequate and is being continued on an industry-by-industry basis.

Scientific studies of the transport and fate of toxics should be linked to engineering work on control technology. This linkage is important, for example, for toxic materials that exist as micro-particles or adsorbed on micro-particles. The Committee is aware of scientific and engineering studies in the Agency which address aerosol transport and control, but is not aware of similar work that characterizes the transport, fate,

micro-particles in aqueous streams. Thus it appears that the linkage between scientific studies and engineering work for control technologies is inadequate.

Because of the large number of toxic materials which could be emitted to the environment, the Agency must develop methods for rapid characterization of the controllability of these materials. Control processes need to be characterized in terms of the operating parameters of the process and the appropriate control data classifying the toxic being removed by the process (e.g., distribution coefficient for extraction processes). The data identifying the ability of the toxic to be removed by a process should be correlated to easily measurable physical and chemical properties of the toxic. TAPCC was briefed on work characterizing "removability" and "treatability" which attempts to meet the above objectives. It is the Committee's opinion that this work needs to be developed on a stronger scientific and technological base and that the effort needs to be coordinated within the Agency. In addition, terminology needs to be carefully defined and research objectives carefully established.

TAPCC was briefed on work to characterize fugitive emissions and the relationship between plant fugitive emissions and plant maintenance. Developing adequate and routine maintenance procedures appears to be the best control measure for fugitive emissions. This program seems to be adequate and its work should be continued.

There appears to be an inadequate amount of research on the removal of extremely toxic substances from waste streams, especially those toxics which produce a harmful effect in concentrations less than parts per billion. This area appears to be a severe shortcoming in the Agency's program.

Most of the research programs were directed toward problem identification. It is the Committee's belief that

research in control technology should be parallel with problem identification rather than sequential to it, so that the appropriate control technology alternatives become available as soon as the extent of the problem indicates the need to implement such control technology.

5.2 Ecological and Health Effects of Toxics

Ecological and health effect studies should relate environmental effects, and basic toxicology studies on test organisms, to safe emission levels for toxic materials. These emission levels are then used as specifications for and help define appropriate control technologies. At IERL-RTP the Multi-media Environmental Goals (MEGs) activity attempts this synthesis of biological data for selecting control processes for toxics. This activity represents a competent initial effort. It was, however, the only research effort that attempted to integrate ecological, health, and control technology information. Further integrated, multi-media methodology and research efforts are required to establish the performance criteria and need for toxics-control technologies.

5.3 Control Technology

Measures must be developed to remove a toxic substance from a waste stream, to detoxify it and/or isolate the material for a sufficiently long time. The control technologies which may be developed should not produce any additional toxics which must be controlled and isolated. The evaluation must also consider that for very toxic materials the following choices may be necessary:

- a) stopping production of the products which create the toxics; or
- b) altering the route of chemical synthesis to minimize or eliminate production of the toxics.

The review revealed many individual, short-term projects responsive to program office needs, e.g., testing water discharges from textile mills and control of emissions from solvent degreasing tanks. There appeared to be little integrated, long-term research efforts. Current research was almost entirely on well established methods for the control of toxics. EPA should increase its research on innovative control technologies.

5.4 Setting Regulations

The Committee's discussions focused primarily on research activities. TAPCC did not investigate how regulators use this information to set standards.

5.5 The Anticipatory Research Center for Advanced Control Technology

This Center was initiated in FY '78, and it is unclear how its efforts will be integrated into EPA's research efforts on the control of toxics. However, it appears that there will be considerable reliance on the Center for the development of "forefront" technology. TAPCC believes that if excessive reliance is placed on this Center for the development of toxics-control technology, to the exclusion of related on-going activities in the EPA laboratories and the integration therewith, EPA's research and regulatory program will not derive optimum benefit.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions of TAPCC and its recommendations are:

1. A wide class of control technologies has demonstrated the ability to reduce effluent concentration levels to the parts per million range. However, many toxics will require control to lower effluent concentrations. The ability to measure low concentrations has progressed rapidly and it is now possible to measure concentrations of toxics in the parts per billion and parts per trillion range. Since there is a movement to regulate emissions at levels of detectability, TAPCC recommends that

- o EPA initiate an effort to identify and develop control technologies that achieve effluent concentrations of toxic substances in the parts per billion (ppb) and parts per trillion (ppt) range so that such control technology will be available when health and ecological studies indicate the need for its application.

2. EPA's research efforts are funded by specific media-oriented legislation. As a result, a multi-media emphasis on control of toxics is lacking. Research related to control technology of toxics has not adequately considered the intermedia transfer of toxics. For example, research on the removal of toxics from wastewater normally does not address the concomitant problem of the disposal of the sludge containing the transferred toxics. TAPCC recommends that

- o EPA attempt to have an integrated toxics control program across all media -- air, water, and land -- so as to avoid technological solutions that merely result in the intermedia transfer of toxics and which do not lead to the effective ultimate disposal of the toxics.

3. Much of EPA's research effort on this subject appears to be directed toward problem identification with less effort directed toward development of new pollution control technology or modifications to improve existing pollution control technology. TAPCC recommends that

- o research in toxics-control technology be parallel with problem identification rather than sequential to it, so that the appropriate control technology alternatives will become available as soon as there is an indication of the need to implement controls.

4. Development and evaluation of new and different control technologies by EPA are necessary if the Agency is to have a sound scientific and technological base for its future regulatory actions. TAPCC recommends that

- o EPA establish a program to develop and evaluate control technologies in terms of their abilities to meet targeted control performance requirements at reasonable cost. Aqueous micro-particle control technology should be included in this program.

5. A program to collect and dispose of toxics after they have been diluted and co-mingled with other wastes or have lost their identity in poorly managed storage and disposal areas is very costly. TAPCC recommends that

- o EPA increase research that will identify how toxics can be minimized or eliminated at the source through in-process change, product substitution, raw material change, or process modification.

6. The potentially large number of toxics which can enter and pollute our environment require that a methodology be developed to rapidly screen and identify the need for control technology for these materials. EPA has begun work in defining and characterizing the ability of a process to remove toxics from waste aqueous streams (i.e., "removability") and the ability of a toxic material to be treated in an aqueous stream (i.e., "treatability"). TAPCC recommends that

- o EPA continue its research in the above area but that activities be coordinated between the program offices and the laboratories. Terminology such as "removability" and "treatability" must be carefully defined or be replaced by terms recognized by the chemical engineering profession such as "separation factor" and "distribution coefficient," and
- o EPA attempt to characterize "removability" with respect to process operating conditions and "treatability" with respect to the physical properties of toxic materials be continued.

7.0 REFERENCES

1. Blair, L.H., Gerber, C.R. and Slosky, L.L., Scientific and Technical Needs for Hazardous Waste Management, The Office of Science and Technology Policy/ Intergovernmental Science, Engineering, and Technology Advisory Panel Staff Report, October 1979.
2. Davies, J.C., Gusman, S., Irwin, F., An Issue Report: Determining Unreasonable Risk Under the Toxic Substances Control Act, The Conservation Foundation, Washington, D.C., 1979.

APPENDIX A

EXAMPLES OF TOXICS-CONTROL RESEARCH IN THE RESPONSIBLE EPA LABORATORIES

Environmental Monitoring Systems Laboratory -- Las Vegas, Nevada

- o Characterization of Hazardous Wastes Identified in the Proposed Hazardous Waste Regulations
- o Evaluation of the Extraction Procedure and Associated Analytical Methods in the Proposed Regulations
- o Evaluation of Sampling Procedures in the Proposed Hazardous Waste Regulations
- o Initiation of a Hazardous Waste Monitoring Quality Assurance Program

Environmental Research Laboratory -- Ada, Oklahoma

- o Behavior of Organic Pollutants in Simulated High-rate Infiltration Systems
- o Bioorganic Indicators of Ground-water Pollution
- o Development of Ground-water Monitoring Techniques For Landfills
- o Direct Injection of Reclaimed Water for Ground-water Recharge
- o Fate of Organic Compounds in Aquifers
- o Fate of Organic Pollutants in a Wastewater Land Treatment System Using Lagoon Impoundment and Spray Irrigation
- o Land Treatment of Petroleum-industry Wastes and Sludges
- o Movement and Fate of Viruses and Organic Pollutants in Ground-water During the Land Treatment of Wastewater

Environmental Research Laboratory -- Athens, Georgia

- o Development of a Master Analytical Scheme for Organics in Water
- o Identification of Non-volatile Organic Compounds Formed During Water Chlorination

APPENDIX A (Continued)

Environmental Research Laboratory -- Athens, Georgia (continued)

- o Prediction of Microbial Transformation of Toxic Substances in Natural Waters and Sediments
- o Sorption Processes in Soils and Water

Industrial Environmental Research Laboratory -- Cincinnati, Ohio

- o Centralized Treatment of Electroplating Sludges
- o Determination of Current Disposal Techniques for High-volume Potentially Toxic Mine Wastes
- o Incineration and Destruction in Cement Kilns

Industrial Environmental Research Laboratory -- Research Triangle Park, North Carolina

- o At-Sea Incineration -- Sampling, Analysis, and Environmental Assessment
- o Development of a Protocol for the Thermal Destruction of PCBs
- o Environmental Assessment of Conventional Combustion Sources for Toxic Emissions and Effluents
- o Evaluation of a Commercial Vacuum System for the Removal of Asbestos
- o Evaluation of PCB Destruction Efficiency for High-efficiency Incineration in Industrial and Utility Boilers
- o Pesticide BATEA Review
- o Pesticide-wastewater "Treatability" Studies
- o Refinement and Development of Technical Support Pesticide-effluent Guidelines
- o Technical and Economical Evaluation of Textiles' BATEA Guidelines

APPENDIX A (Continued)

Industrial Environmental Research Laboratory -- Research
Triangle Park, North Carolina (continued)

- o Technical Services and Support Information for the
Asbestos Abatement Program
- o TSCA-pollutant Prioritization-strategy Model

Municipal Environmental Research Laboratory -- Cincinnati,
Ohio

- o Air Pollution Sampling and Monitoring at Hazardous Waste
Facilities
- o Development of Pilot Scale Microwave Plasma Detoxification
Process for Hazardous Wastes
- o Development of Safe Methods for Disposal of Excess Pesticides
Used by Farmers and Applicators
- o Economic Analysis of Hazardous Waste Treatment/Control
Technology
- o Evaluation of Hazardous Waste Storing, Sampling, Analysis,
and Compatibility
- o Laboratory and Field Evaluation of Chemically Stabilized
Sludges
- o Laboratory and Field Evaluation of Processes and Materials
for Encapsulating Containers Holding Hazardous Wastes
- o Predicting Movement of Selected Metals in Soils; Application-
to-disposal Problems
- o Testing Protocols and Data Requirements for Statements on
Pesticide Container Labels
- o Toxicity--Testing, Methods Development and Validation

APPENDIX B

TECHNOLOGY ASSESSMENT AND POLLUTION CONTROL COMMITTEE

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