

Research and Development



# Health Assessment Document for 1,2-Dichloroethane (Ethylene Dichloride)

## Review Draft

(Do Not  
Cite or Quote)

## Part 2 of 2

### NOTICE

This document is a preliminary draft. It has not been formally released by EPA and should not at this stage be construed to represent Agency policy. It is being circulated for comment on its technical accuracy and policy implications.

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## PREFACE

The Office of Health and Environmental Assessment has prepared this health assessment to serve as a "source document" for EPA use. The health assessment document was originally developed for use by the Office of Air Quality Planning and Standards to support decision-making regarding possible regulation of ethylene dichloride as a hazardous air pollutant. However, the scope of this document has since been expanded to address multimedia aspects.

In the development of the assessment document, the scientific literature has been inventoried, key studies have been evaluated and summary/conclusions have been prepared so that the chemical's toxicity and related characteristics are qualitatively identified. Observed effect levels and other measures of dose-response relationships are discussed, where appropriate, so that the nature of the adverse health responses are placed in perspective with observed environmental levels.

The EPA's Office of Health and Environmental Assessment (OHEA) is responsible for the preparation of this health assessment document. The OHEA Environmental Criteria and Assessment Office (ECAO-RTP) had overall responsibility for coordination and direction of the document (Dr. Robert M. Bruce, Project Manager). The chapters addressing physical and chemical properties, sampling and analysis and toxic effects were either rewritten or revised by Syracuse Research Corporation. The pharmacokinetics chapter was written by Dr. I.W.F. Davidson of the Bowman Gray School of Medicine, Wake Forest University. The air quality chapters addressing sources, emissions and ambient concentrations were originally written by Syracuse Research Corporation and revised by Radian Corporation under a contract with the Office of Air Quality Planning and Standards.

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## 10. REFERENCES

Agranovich, B.Y.A. 1948. Clinical Treatment and Pathology of Toxicologic-chemical Injuries of the Liver in the Case of Industrial Poisoning. Moscow, USSR, Academy of Medical Science. p. 132-143. (Summarized in NIOSH, 1976).

Akimo, G.A., V.M. Buchko and I.P. Iolesnichenko. 1976. Changes in the nervous system in acute dichloroethane poisoning. Voenno-meditsinskiy Zhurnal. 5: 35-37.

Akimo, G.A., V.M. Buchko and I.P. Kolesnichenko. 1978. Neurological disorders in acute dichloroethane poisoning. Zh. Nevropatol. Piskhiatr. 78(5): 687-692.

Altshuller, A.P. 1979. Lifetimes of organic molecules in the troposphere and lower stratosphere. Advances in Environmental Science and Technology. 10: 181-219.

Altshuller, A.P. and P.L. Hanst. 1975. Report on the Problem of Halogenated Air Pollutants and Stratospheric Ozone. EPA-600/9-75-008, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC

Ambrose, A. 1950. Toxicological studies of compounds investigated for use as inhibitors of biological processes. II. Toxicity of ethylene chlorohydrin. Arch. Inc. Hyg. Occup. Med. 2: 591-597.

Amoore, J.E. and D. Venstrom. 1966. Sensory analysis of odor qualities in term of the stereochemical theory. J. Food. Science. 31: 118.

Anders, M.W. and J.C. Livesey. 1980. Metabolism of 1,2-dihaloethanes, in "Banbury Report No. 5, Ethylene Dichloride: A Potential Health Risk?", B. Ames, P. Infante and R. Reitz, eds., Cold Spring Harbor Laboratory, p. 331-343.

Andriukin, A.A. 1979. Toxic effects of dichloroethane on the cardiovascular system. Klin. Med. 57: 43-47 (Rus.) (Summarized in Chem. Abstr. 79: 2088, 1977).

Anonymous. 1946. Ethylene Dichloride, in Annual Report of the Chief Inspector of Factories for the Year 1945. London, His Majesty's Stationery Office. p. 77. (Summarized in NIOSH, 1976).

Appleby, A. 1976. Atmospheric Freons and Halogenated Compounds. EPA-600/3-76-108, Office of Research and Development, U.S. Environmental Protection Agency.

Archer, W.L. 1979. 1,2-Dichloroethane. In: Kirk-Othmer Encyclopedia of Chemical Technology, Third Edition., Grayson, M. and Eckroth, D., eds. John Wiley and Sons, Inc., NY. Vol. 5, p. 724-727.

Archer, W.L. 1979. Other Chloroethanes. In: Kirk-Othmer Encyclopedia of Chemical Technology, Third Edition, Grayson, M. and Eckroth, D., eds. John Wiley and Sons, Inc., NY. Vol. 5, p. 722-742.

Armitage, P. and R. Doll. 1954. The age distribution of cancer and a multistage theory of carcinogenesis. Br. J. Cancer. 8: 1-12.

Auerbach Associates. 1978. Miscellaneous and Small Volume Consumption of Ethylene Dichloride. Unpublished report prepared for the U.S. Environmental Protection Agency under contract number EPA-68-01-3899 and Auerbach Associates, Inc., number AAI-2431-104-TN-1, Philadelphia, PA, p. 7.

Baader, E.W. 1950. Multiple poisonings from a floor cleaner because of failure to observe safety laws. Arch. Hyg. Bakterirol. 132: 219-226. (Ger.) (Summarized in NIOSH, 1976).

Banerjee, S. and B.L. Van Duuren. 1978. Interaction of activated carcinogenic intermediates of ethylene dihalides with protein and DNA in mice and rat tissue in vitro. Proc. Amer. Assoc. Cancer Res. 19: 67.

Banerjee, S. and B.L. Van Duuren. 1979a. Binding of carcinogenic halogenate hydrocarbons to cellular macromolecules. J. Natl. Cancer Inst. 63: 707.

Banerjee, S., B.L. Van Duuren and S.A. Kline. 1979b. Interaction of potential metabolites of the carcinogen ethylene dibromide with protein and DNA in vitro. Biochem. Biophys. Res. Comm. 90: 1214-1220.

Banerjee, S., B.L. Van Duuren and F.I. Oruambo. 1980. Microsome-mediated covalent binding of 1,2-dichloroethane to lung microsomal protein and salmon sperm DNA. Cancer Res. 40: 2170-2173.

Bang, Y.H. and H.S. Telford. 1966. Effect of sublethal doses of fumigants on stored-grain insects. Technical Bulletin 50. Washington Agricultural Experiment Station, Washington State University.

Barber, E.D., W.J. Donish and K.R. Mueller. 1981. A procedure for the quantitative measurement of the mutagenicity of volatile liquids in the Ames Salmonella/microsome assay. *Mutat. Res.* 90: 31-48

Barrows, M.E., S.R. Petrocelli, K.J. Macek and J.J. Carrell. 1980. Bioconcentration and elimination of selected water pollutants by bluegill sunfish (Lepomis macrochirus). In: Dynamics, Exposure, and Hazard Assessment of Toxic Chemicals. R. Haque, ed. Ann Arbor Science, Ann Arbor, MS. p. 379-392.

Barsoum, G.S. and K. Saad. 1934. Relative toxicity of certain chlorine derivatives of the aliphatic series. *Quart. J. Pharm. Pharmacol.* 7: 205-214.

Bellamy, R. and W. Schwartz. 1975. Engineering and Cost Study of Air Pollution Control for the Petrochemical Industry: Vinyl Chloride Manufacture by the Balanced Process. Volume 8. EPA-450/3-73-006h. Houdry Division of Air Products and Chemicals, Inc. Report prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC.

Benoit, D.A., F.A. Puglisi and D.L. Olson. 1982. A fathead minnow Pimphales promelas early life stage toxicity test method evaluation and exposure to four organic chemicals. *Environ. Pollut., Ser. A.* 28(3): 189-97.

Berck, B. 1974. Fumigant residues of carbon tetrachloride, ethylene dichloride, and ethylene dibromide in wheat, flour, bran, middlings, and bread. J. Agric. Food Chem. 22(6): 977-984.

Berck, B. 1965. Sorption of ethylene dibromide, ethylene dichloride, and carbon tetrachloride by cereal products. J. Agric. Food Chem. 13: 248-254.

Blackford, J.L. 1974. Ethylene Dichloride. In: Chemical Economics Handbook. Menlo Park, CA: Stanford Research Institute, p. 651.5031a-651.5032z.

Bloch, W. 1946. Two poisonings from dichloroethane used for purposes of inebriation. Schweiz Med. Wochenschr. 76: 1078-1079. (Ger.) (Summarized in NIOSH, 1976).

Bogoyavlenski, V.F., S.K.H. Salikhova and E.V. Karpova. 1968. Clinical aspects and therapy for ethylene dichloride poisoning. Sov. Med. 31: 107-109. (Summarized in NIOSH, 1976).

Bolt, H.M. 1978. Pharmacokinetics of vinyl chloride. Gen. Pharmacol. 9: 91.

Bonitenko, Y.Y. 1974. Aspartate-amino-transferase isoenzymes in acute dichloroethane poisoning. Gigiena Truda i Professional'nye Zaboilevaniga. 7: 46-47.

Bonitenko, Y.Y., A.A. Bruk, Ye. A. Belouson and M.F. Lebeden. 1977. Veomno-Meditsinskiy Zhurnal. 11: 75-77.

Borisova, M.K. 1957. Experimental data for determination of the maximum allowable concentration of dichloroethane in the atmosphere. *Gig. Sanit.* 22: 13-19. (Rus.) (Summarized from English Translation).

Bouwer, E.J. and P.L. McCarty. 1983. Transformations of 1- and 2-carbon halogenated aliphatic organic compounds under methanogenic conditions. *Appl. Environ. Microbiol.* 45: 1286-1294.

Bozzelli, J.W. and B.B. Kebbekus. 1979. "Analysis of Selected Volatile Organic Substances in Ambient Air," prepared for New Jersey Department of Environmental Protection, New Jersey Institute of Technology, NJ. NTIS PB 80-144694.

Bozzelli, J.W., B.B. Kebbekus and A. Greenburg. 1980. Analysis of selected toxic and carcinogenic substances in ambient air. Prepared for Office of Cancer and Toxic Substances Research, New Jersey Department of Environmental Protection.

Brass, K. 1949. Concerning a lethal dichloroethane poisoning. *Deutsch. Med. Wochenschr.* 74: 553-554. (Ger.) (Summarized in NIOSH, 1976).

Brass, H.J. 1981. An overview of organics data: Community Water Supply Survey and Rural Water Survey. Technical Support Division, Drinking Water Quality Assessment Branch, U.S. Environmental Protection Agency.

Bray, H., W. Thorpe and D. Vallance. 1952. The liberation of chloride ions from organic chlorocompounds by tissue extracts. *Biochem. J.* 51: 193-201.

Brem, H., A.B. Stein and H.S. Rosenkranz. 1974. The mutagenicity and DNA-modifying effects of haloalkanes. Cancer Res. 34: 2576-2579.

Brodzinsky, R. and H.B. Singh. 1982. Volatile Organic Chemicals in the Atmosphere: Assessment of Available Data. Prepared for the U.S. EPA under contract No. 68-02-3452 by Stanford Research Institute International, Menlo Park, CA.

Brown, R.H. and Purnell, C.J. 1979. Collection and Analysis of Trace Organic Vapor Pollutants in Ambient Atmospheres. The performance of a Tenax GC adsorbent Tube. J. Chromat. 178: 79-90.

Bryzhin, F.F. 1945. Pathomorphological changes of internal organs in connection with poisoning by ethylene dichloride through the digestive tract. Farmakol. Toksikol. 8(5): 43-49. (Rus.) (Summarized in NIOSH, 1976).

Brzozowski, J., J. Czajka, T. Dutkiewicz, I. Kesy and J. Wojcik. 1954. Work hygiene and the health condition of workers occupied in combating the Leptinotarsa decemlineata with HCH and dichloroethane. Med. Pracy. 5: 89-98. (Pol.) (Summarized in NIOSH, 1976).

Buccafusco, R.J., S.J. Ellis and G.A. LeBlanc. 1981. Acute toxicity of priority pollutants to bluegill (*Lepomis macrochirus*). Bull. Environ. Contam. Toxicol. 26(4): 446-52.



Burns, L.A., D.M. Cline and R.R. Lassiter. 1982. Exposure Analysis Modeling System (EXAMS): User Manual and System Documentation. U.S. EPA Report No. EPA-600/3-82-023, Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA. 443 p.

Butler, R., I.J. Solomon and A. Snelson. 1978. Rate constants for the reaction of OH with halocarbons in the presence of  $O_2 + N_2$ . J. Air Pollut. Control Assoc. 28(11): 1131-1133.

Byers, D.H. 1943. Chlorinated solvents in common wartime use. Ind. Med. 12: 440.

Catalytic. 1979. Draft Summary Report of BAT-308 Responses.

Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Folwer, J.R. Freed, et al. 1979. Water-Related Environmental Fate of 129 Priority Pollutants. Vol. II. U.S. EPA Report No. EPA-440/4-79-029b, Office of Water Planning and Standards, Office of Water and Waste Management, U.S. Environmental Protection Agency, Washington, DC.

Calvert, J.G. 1976. Hydrocarbon involvement in photochemical smog formation in Los Angeles atmosphere. Environ. Sci. Technol. 10: 256-262.

Cetnarowicz, J. 1959. Experimental and clinical studies on effects of dichloroethane. Folia. Med. Cracov. 1: 169-192. (Pol.) (Summarized from English Translation).

Chemical and Engineering News. 1979. Key Chemicals - Vinyl Chloride. C and EN, June 24, 1979, p. 18.

Chemical and Engineering News. 1982. Key chemicals - Vinyl Chloride. C and EN, June 21, 1982, p. 18.

Chemical and Engineering News. 1983. Key Polymers - Vinyl Chloride. C and EN, June 20, 1983, p. 17.

Chemical Economics Handbook. 1975. SRI International.

Chemical Economics Newsletter. 1978. SRI International.

CMR (Chemical Marketing Reporter). 1974. Chemical Profile - Ethylene Dichloride. Chemical Marketing Reporter, June 10, 1974.

CMR (Chemical Marketing Reporter). 1977. Chemical Profile - Ethylene Dichloride. Chemical Marketing Reporter, May 16, 1977.

CMR (Chemical Marketing Reporter). 1980. Chemical Profile - Ethylene Dichloride. Chemical Marketing Reporter, May 5, 1980.

CMR (Chemical Marketing Reporter). 1982. Chemical Profile - Lead Alkyls. Chemical Marketing Reporter, February 1, 1982.

CMR (Chemical Marketing Reporter). 1983. Chemical Profile - Ethylene Dichloride. Chemical Marketing Reporter, June 13, 1983.

Chiou, C.T., L.J. Peters and V.H. Freed. 1979. A physical concept of soil-water equilibria for nonionic organic compounds. Science. 206: 831-832.

Chiou, C.T., V.H. Freed, L.J. Peters and R.L. Kohnert. 1980. Evaporation of solutes from water. Environ. International. 231-236.

Coleman, W.E., R.D. Lingg, R.G. Melton and F.C. Koppler. 1976. The occurrence of volatile organics in five drinking water supplies using gas chromatography-mass spectrometry. Identif. Amal. Org. Pollut. Water. (Chem. Congs. North Amer. Cont.) 1st 1975, Ann Arbor Sci., Ann Arbor, MI. p. 305-327.

The Condensed Chemical Dictionary. 1977. Nine edition. G.G. Hawley, ed., Van Nostrand Reinhold Company, NY.

Conkle, J.P., B.J. Camp and B.E. Welch. 1975. Trace composition of human respiratory gas. Arch. Environ. Health. 30(6): 290-295.

Cooper, C.V., L.D. White and R.E. Kupel. 1971. Qualitative detection limits for specific compounds utilizing gas chromatographic fractions, activated charcoal, and a mass spectrometer.

Cox, C.B. 1972. Regression model and life tables. J. Roy. Stat. Soc. B. 34: 187-220.

Crump, K.S. and W.W. Weston. 1979. GLOBAL79. A Fortran program to extrapolate dichotomous animal carcinogenicity data to low dose. Natl. Inst. Environ. Health Science Contract No. 1-ES-2123.

Crump, K.S., H.A. Guess and L.L. Deal. 1977. Confidence intervals and test of hypotheses concerning dose-response relations inferred from animal carcinogenicity data. Biometric. 33: 437-451.

Crutzen, P.J. and J. Fishman. 1977. Average concentrations of  $\cdot\text{OH}$  in the troposphere and the budgets of  $\text{CH}_4$ ,  $\text{CO}$ ,  $\text{H}_2$ , and  $\text{CH}_3\text{CCl}_3$ . Geophys. Res. Lett. 4: 321-324.

Cupitt, L.T. 1980. Fate of Toxic and Hazardous Materials in the Air Environment. U.S. EPA Report No. EPA-600/S3-80-084, Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC. Available through NTIS Order No. PB80-221948, Springfield, VA.

Daffer, P., K. Crump and M. Masterman. 1980. Asymptotic theory for analyzing dose-response survival data with application to low-dose extrapolation problem. Mathematical Biosciences. 50: 207-230.

Danz, M. and H. Urban. 1979. Carcinogens, promoters, and suspicious drugs: Their identical short-term effect in a promoting activity test (PAT). Exp. Pathol. 17: 181-184.

Deinzer, M, F. Schaumburg and E. Klein. 1978. Environmental Health Sciences Center. Task Force Review of Halogenated Organics in Drinking Water. Environ. Health Persp. 24: 209-239.

Delplace, Y. A. Cavigneaux and G. Cabasson. 1962. Occupational disorders due to methylene chloride and dichloroethane. Arch. Mal. Prof. 23: 816-817. (Fr.) (Summarized in NIOSH, 1976).

Dilling, W.L., N.B. Tefertiller and G.J. Kallos. 1975. Evaporation rates and reactivities of methylene chloride, chloroform, 1,1,1-trichloroethane, trichloroethylene, tetrachloroethylene, and other chlorinated compounds in dilute aqueous solutions. Environ. Sci. Technol. 9(9): 833-838.

Doll, R. 1971. Weibull distribution of cancer: Implications for models of carcinogenesis. J. Roy. Stat. Soc. A13: 133-166.

Domenici, F. 1955. Granosan intoxication. Rass. Clin-Sci. 31: 70-73. (Ita.) (Summarized in NIOSH, 1976).

Dowty, B.J., D.R. Carlisle and J.L. Laseter. 1975. New Orleans drinking water sources tested by gas chromatography-mass spectrometry. Environ. Sci. Technol. 9: 762-765.

Dripps, R.D., J.E. Eckenhoff and L.D. Vandam. 1977. Introduction to anesthesia: The principles of safe practice. 5th edition. W.B. Saunders Company, Philadelphia, PA. p. 121-123.

Drury, J.S. and A.S. Hammons. 1979. Investigations of selected environmental pollutants: 1,2-dichloroethane. Oak Ridge National Laboratory/EIS-148. U.S. Environmental Protection Agency 560/2-78-006.

Edwards, K., H. Jackson and A.R. Jones. 1970. Studies with alkylating esters. II. A chemical interpretation through metabolic studies of the antifertility effects of ethylene dimethanesulphonate and ethylene dibromide. Biochem. Pharmacol. 19: 1783.

Ehrenberg, L., S. Osterman-Golkar, D. Singh and U. Lundquist. 1974. On the reaction kinetics and mutagenic activity of methylating and -halogenating gasoline additives. Radiation Botany. 15: 185-194.

Eimutis, E.C. and R.P. Quill. 1977. Source Assessment: Non-criteria Pollutant Emissions. EPA-600/2-77-107e. Monsanto Research Corp., Dayton, OH. Report prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC.

Elfers, L. 1979. "Monitoring of Ambient Levels of Ethylene Dichloride (EDC) in the Vicinity of EDC Production and User Facilities," prepared for U.S. Environmental Protection Agency by PEDCO Environmental, Inc., Cincinnati, OH. NTIS PB-298303, EPA 600/4-79-029.

Ellis, C.R. and F.O. Morrison. 1967. Small chamber tests of ethylene dibromide and ethylene dichloride on adult grain-infesting coleoptera. Canad. J. Zoology. 45: 435-448.

Ehrenberg, L., S. Osterman-Golkar, D. Singh and U. Lindquist. 1974. On the reaction kinetics and mutagenic activity of methylating and  $\beta$ -halogenethylating gasoline additives. Rad. Botany. 15: 185-194.

Ethylene Dichloride. In: Annual Report of the Chief Inspector of Factories for the Year 1945. London, His Majesty's Stationary Office, p. 77. 1946.

Ewing, B.B., E.S.K. Chian, J.C. Cook, C.A. Evans, P.K. Hopke and E.G. Perkins. 1977. Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters. EPA-560/6-77-015. U.S. Environmental Protection Agency. Office of Toxic Substances. p. 63-64, 73.

Fabricant, J.D. and J.G. Chalmers, Jr. 1980. Evidence of mutagenicity of ethylene dichloride and structurally related compounds. In: Banbury Report 5. Ethylene Dichloride: A potential health risk? B.N. Ames, P. Infante and R. Reitz, eds. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY. p. 309-329.

Federal Register. 1971. 36(288): 22542.

Federation of American Societies for Experimental Biology (FASEB). 1974. 2nd edition. Vol. III. Philip L. Altman and Dorothy S. Dittman, Eds. Bethesda, MD. Library of Congress No. 72-87738.

Finnegan, R.J. and K.E. Stewart. 1962. Control of the pine root collar weevil, Hylobius radicus. J. Econ. Entomol. 55(4): 483-486.

Filser, J.G. and H.M. Bolt. 1979. Pharmacokinetics of halogenated ethylenes in rats. Arch. Toxicol. 42: 123.

Fishbein, L. 1976. Industrial mutagens and potential mutagens. I. Halogenated aliphatic derivatives. Mutat. Res. 32: 267-308.

Fishbein, L. 1979. Potential halogenated industrial carcinogenic and mutagenic chemicals. III. Alkane halides, alkanols and ethers. Science of the Total Environment. 11: 223-257.

Flowtow, E. 1952. Poisoning due to chlorinated hydrocarbon compounds, particularly 1,2-dichloroethane. Chem. Tech. (Berlin) 6: 253-254. (Summarized in NIOSH, 1976).

Freundt, K.J., H. Eberhardt and U.M. Walz. 1963. Lethal peroral poisoning with 1,2-dichloroethane and 2,2-dichlorodiethylether. Int. Arch. Gewerbepathol. Gewerbehyg. 20: 41-48. (Ger.) (Summarized in NIOSH, 1976).

Fujii, T. 1977. Direct aqueous injection chromatograph-mass spectrometry for analysis of organohalides in water at concentrations below the part per billion level. J. Chromatogr. 139: 297-302.

Garrett, J.T. 1957. Toxicity investigations on aquatic and marine life. Public Works. 88(12): 95-96.

Garrett, J.T. 1957. Toxicity considerations in pollution control. Indust. Wastes. 2: 17-19.



Garrison, S.C. and R.S. Leadingham. 1954. A fatal case of ethylene dichloride poisoning in an occupational therapy department of a neuropsychiatric hospital. Amer. J. Phys. Med. 33: 230-237.

Gast, R. and J. Early. 1956. Phytotoxicity of solvents and emulsifiers used in insecticide formulations. Agricul. Chem. ? : 42-45, 136-139.

Gehring, P.J., P.G. Watanabe and J.D. Young. 1977. The relevance of dose-dependent pharmacokinetics in the assessment of carcinogenic hazard of chemicals. Cold Spring Harbor Conf. Cell Proliferation 4: 187.

Gehring, P.J., P.G. Watanabe and G.E. Blau. 1976. Pharmacokinetic studies in the evaluation of the toxicological and environmental hazards of chemicals. In: Advances in Modern Toxicology, M.A. Mehlman, R.E. Shapiro and H. Blumenthal, eds., vol. 1, part 1, Washington, DC: Hemisphere Publishing Co.

Gehring, P.J., P.G. Wantabe and C.N. Park. 1978. Resolution of dose response toxicity data for chemicals requiring metabolic activation: Example - vinyl chloride. Toxicol. Appl. Pharmacol. 44: 531.

Gikalov, G.S., K.A. Chemanaev and M.U. Janda. 1969. Clinic and treatment of dichloroethane poisoning. Voен-med. Zh. 4: 78-79. (Rus.) (Summarized in NIOSH, 1976).

Gold, L. 1980. Pages 209-226 in B. Ames, P. Infante and R. Reitz, Eds. Banbury Report No. 5. Ethylene dichloride: A potential health risk? Cold Spring Harbor Laboratory.

Grimsrud, E. and R. Rasmussen. 1975. Survey and analysis of halocarbons in the atmosphere by gas chromatography--mass spectrometry. Atmos. Environ. 9: 1014-1017.

Guarino, A. and N. Lioia. 1958. Clinical and histopathological findings on a fatal poisoning with Granosan. Folia. Med. (Napoli). 41: 676-690. (Summarized in NIOSH, 1976).

Guengerich, F.P., W.M. Crawford, J.Y. Domoredzki, T.L. McDonald and P.G. Watanabe. 1980. In vitro activation of 1,2-dichloroethane by microsomal and cytosolic enzymes. Toxicol. Appl. Pharmacol. 55: 303-317.

Guerdjikoff, C. 1955. Acute and chronic occupational intoxication by symmetric dichloroethane. Doctoral thesis No. 2325. Geneva, Switzerland, University of Geneva, Faculty of Medicine. 107 p. (Fr.) (Summarized in NIOSH, 1976).

Hadengue, A. and R. Martin. 1953. A case of fatal poisoning by dichloroethane. Soc. Med. Leg. 33: 247-249. (Fr.) (Summarized in NIOSH, 1976).

Handbook of Environmental Data on Organic Chemicals. 1977. K. Verschueren, ed., Van Nostrand and Co., NY.

Hanst, P.L. 1978. Part II. Halogenated pollutants: Noxious trace gases in the air. Chemistry. 51(2): 6-12.

Hardie, D.W.F. 1964. Chlorocarbons and chlorohydrocarbons. In: Kirk-Othmer The Encyclopedia of Chemical Technology, 2nd ed., volume 5, Interscience Publishers, NY. p. 152-154.

Hawley, G.G. 1981. The Condensed Chemical Dictionary. Tenth edition. Van Nostrand Reinhold Co., NY. p. 431.

Hayes, F.D., R.D. Short and J.E. Gibson. 1973. Differential toxicity of mono-chloroacetate, monofluoroacetate and moniodoacetate in rats. Toxicol. Appl. Pharmacol. 26: 93-102.

Heitmuller, P.T., T.A. Hollister and P.R. Parrish. 1981. Acute toxicity of 54 industrial chemicals to sheepshead minnows (Cyprinodon variegatus). Bull. Environ. Contam. Toxicol. 27(5): 596-604.

Hellman, T.M. and F.H. Small. 1973. Characterization of odors from the petrochemical industry. Chem. Eng. Progr. 69: 75.

Hellman, T.M. and F.H. Small. n.d. Characterization off the odor properties of 101 petrochemicals using sensory methods. J. Air Pollution Control Assoc. 24: 979-982.

Heppel, L.A., P.A. Neeal, T.L. Perrin, K.M. Endicott and V.T. Porterfield. 1945. Toxicology of 1,2-dichloroethane. III. Its acute toxicity and the effect of protective agents. J. Exp. Pharmacol. Ther. 83: 53-63.

Heppel, L.A., P.A. Neal, T.L. Perrin, K.M. Endicott and V.T. Porterfield. 1946. Toxicology of 1,2-dichloroethane. V. Effects of daily inhalations. J. Ind. Hyg. Toxicol. 28: 113-120.

Heppel, L.A., V.T. Porterfield and N.G. Sharpliss. 1947. Toxicology of 1,2-dichloroethane. IV. Its detoxification by L-cystine, D.L.-methionine and certain other sulfur-containing compounds. J. Pharmacol. Exp. Ther. 91: 385-394.

Heppel, L.A. and V.T. Porterfield. 1948. Enzymatic dehalogenation of certain brominated and chlorinated compounds. J. Biol. Chem. 176: 763-769.

Heukelekian, H. and M.C. Rand. 1955. Biochemical oxygen demand of pure organic compounds. J. Water Pollut. Control Assoc. 29: 1040-1053.

Hill, D.T., T.-W. Shih, T.P. Johnston and R.F. Struck. 1978. Macromolecular binding and metabolism of the carcinogen 1,2-dibromoethane. Cancer Research. 28: 2438.

Hinkel, G.K. 1965. Oral dichloroethane poisoning in children. Deutsche Gesundheitswesen. 20: 1327-1331.

Hobbs, F.D. and J.A. Key. 1978. Emissions Control Options for the Synthetic Organic Chemicals Manufacturing Industry. Draft report. EPA contract number 68-02-2572. Hydroscience, Inc., Knoxville, TN. Report prepared for Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Holman, H.T., H. Birnstiel and P. Jobst. 1971. On the inhalation toxicity of 1,1- and 1,2-dichloroethane. Arch. Toxicology. 27: 248.

Hooper, K., L. Gold and B. Ames. 1980. Pages 65-82 in B. Ames, P. Infante and R. Reitz, Eds. Banbury Report No. 5. Ethylene dichloride: A potential health risk? Cold Spring Harbor Laboratory.

Howard, C.J. and K.M. Evenson. 1976. Rate constants for the reactions of OH with ethane and some halogen substituted ethanes at 296°K. J. Chem. Phys. 64(11): 4303-4306.

Howe, R.B. and K.S. Crump. 1982. A computer program to extrapolate quantal animal animal toxicity data to low doses. OSHA Contract 41 USC252C3.

Hueper, W.C. and C. Smith. 1935. Fatal ethylene dichloride poisoning. Amer. J. Med. Sci. 189: 778-784.

Hulst, J.P.L., A.J. Steenhauer and D.L. Keede. 1946. Lethal poisoning with dichloroethane. Ned. Tijdschr Geneesk. 90: 406-407. (Dut.) (Summarized in NIOSH, 1976).

Ienistea, C. and M.D. Mezincesco. 1943. Fatal poisoning by ingestion of ethylene dichloride. Bull. Acad. Med. Roum. 8: 614-617. (Fr.) (Summarized in NIOSH, 1976).

International Agency for Research on Cancer. 1979. Monograph on the evaluation of carcinogenic risk of chemicals to humans. 20: 429-448.

International Commission on Radiological Protection (ICRP). 1977. Recommendation of the ICRP, Pub. No. 26, adopted Jan. 17, 1977. Oxford, England: Pergamon Press.

Irish, D. n.d. Halogenated hydrocarbons, J. Aliphatics. In: Industrial Hygiene and Toxicology, Vol. 2, F.A. Patty, ed. NY: Interscience, p. 1280-1284.

Irish, D.D. 1963. Aliphatic Halogenated Hydrocarbons. In: Industrial Hygiene and Toxicology. Second revised edition, D.W. Fassett and D.D. Irish, eds., Interscience Publishers.

Ivanetick, K.M., S. Lucas, J.A. March, M.R. Ziman, I.D. Katz and J.J. Bradshaw. 1978. Organic compounds. Their interaction with and degradation of hepatic microsomal drug-metabolizing enzymes in vitro. Drug Met. Dispos. 6(3): 218-225.

Jaeger, R.J., R.B. Conolly and S.D. Murphy. 1974. Effect of 18-hour fast and glutathione depletion on 1,1-dichloroethyl-induced hepatotoxicity and lethality in rats. Exp. Mol. Pathol. 20: 187-198.

Jaeger, R.J. 1979. Time-related variation of non-protein sulhydryl concentrations in rat tissue and human blood. Int. Arch. Occup. Environ. Health. 42: 141-148.

Jakobson, I., J.E. Wahlberg, B. Holmberg and G. Johansson. 1982. Uptake via the blood and elimination of 10 organic solvents following epicutaneous exposure of anesthetized guinea pigs. Toxicol. Appl. Pharmacol. 63: 181-187.

Jenssen, D. and C. Ramel. 1980. The micronucleus test as part of a short-term mutagenicity test program for the prediction of carcinogenicity evaluated by 143 agents tested. *Mutat. Res.* 75: 191-202.

Johnson, M.K. 1965. The influence of some aliphatic compounds on rat liver glutathione levels. *Biochem. Pharmacol.* 14: 1383-1385.

Johnson, M.K. 1966a. Metabolism of iodomethane in the rat. *Biochem. J.* 98: 38-43.

Johnson, M.K. 1966b. Studies on glutathione S-alkyltransferase of the rat. *Biochem. J.* 98: 44-56.

Johnson, M.K. 1967. Metabolism of chloroethanol in the rat. *Biochem. Pharmacol.* 16: 185-199.

Jones, A.R. and K. Edwards. 1968. The comparative metabolism of ethylene dimethanesulphonate and ethylene dibromide. *Experientia.* 24: 1100-1101.

Jordi, A. 1944. Industrial poisonings due to symmetrical 1,2-dichloroethane. *Z. Unfallmed. Berufskr.* 37: 131-136. (Ger.) (Summarized in NIOSH, 1976).

Kaira, F.M. 1966. Alimentary oral dichloroethane poisoning. *Klin. Med. Mosk.* 44: 143-146. (Rus.) (Summarized in NIOSH, 1976).

Kaplan, E. and P. Meier. 1958. Nonparametric estimation from incomplete observations. *J. American Statistical Assoc.* 52: 457-481.

Kellam, R.G. and M.G. Dusetzina. Human exposure to ethylene dichloride: Potential for regulation via EPA's proposed airborne carcinogen policy. In: Banbury Report No. 5 Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds. Cold Springs Harbor Laboratory, p. 265-274.

Kenaga, E.E. 1980. Predicted bioconcentration factors and soil sorption coefficients of pesticides and other chemicals. *Ecotoxicol. Environ. Safety*. 4: 26-38.

Keyzer, J.L. 1944. Lethal poisoning by dichloroethane. *Ned. Tijdschr. Geneesk.* 88: 641. (Dut.) (Summarized in NIOSH, 1976).

King, M.T., H. Beikirch, K. Echkhardt, E. Gock and D. Wild. 1979. Mutagenicity studies with x-ray contrast media, analgesics, antipyretics, antirheumatics, and some other pharmaceutical drugs in bacterial, Drosophila and mammalian test systems. *Mutat. Res.* 66: 33-43.

Kirk-Othmer. 1964. *Encyclopedia of Chemical Technology*.

Kirichek, Iu. F. 1974. Effects of 1,2-dichloroethane. *Usp. Khim. Mutageneze Sel.* 232-235.

Kistler, G.H. and A.B. Luckhardt. 1929. Die 13 wichtigsten chlorkohlenwasserstoffe der fettreihe vom standpunkt der gewerbehygiene. *Anesth. Analg.* 8: 65-78.



Kokarovtseva, M.G. and N.J. Kiseleva. 1978. Chloroethanol, one of the toxic metabolites of 1,2-dichloroethane. Farmakol. J. Toksikol. 41: 118-120.

Kovar, J. and D. Krewski. 1981. RISK81: A computer program for low-dose extrapolation of quantal response toxicity data. Department of Health and Welfare, Canada.

Kozik, I. 1957. Problems of occupational hygiene in the use of dichloroethane in the aviation industry. Gig. Tr. Prof. Zabol. 1: 31-38. (Rus.) (Summarized from English Translation).

Kristoffersson, U. 1974. Genetic effects of some gasoline additives. Hereditas. 78: 319.

Krohne, H.E. and D.L. Lingren. 1958. Susceptibility of Life Stages of Sitophilus oryza to various fumigants. J. Econ. Entomol. 51(2): 157-158.

Lane, R.W., B.L. Riddle and J.F. Borzelleca. 1982. Effects of 1,2-dichloroethane and 1,1,1-trichloroethane in drinking water on reproduction and development in mice. Toxicol. Appl. Pharmacol. 63: 409-421.

Larkin, R.L., J.V. Crable, L.R. Catlett and M.J. Seymour. 1977. Collaborative testing of a gas chromatographic charcoal tube method for seven organic solvents. Amer. Ind. Hyg. Assoc. 38: 543-553.

Lehmann, K.B. and L. Schmidt-Kehl. 1936. The pharmacology of some ethylene-halogen compounds. Arch. J. Hyg. 116: 131-143.

Letkiewicz, F., P. Johnston, J. Colman, et al. 1982. Occurrence of 1,2-Dichloroethane in Drinking Water, Food and Air. EPA Contract No. 68-01-6185, Task 11.

Lindgren, D.L., L.E. Vincent and H.E. Krohne. 1954. Relative effectiveness of 10 fumigants to adults of 8 species of stored-product insects. J. Econ. Entomol. 47(5): 923-926.

Lindgren, D.L. and L.E. Vincent. 1959. J. Econ. Entomol. 52: 1091.

Lindgren, D.L., W.B. Sinclair and L.E. Vincent. 1968. Residues in raw and processes foods resulting from post-harvest insecticidal treatments. In: Residue Reviews, volume 21, F.A. Gunther, ed., Springer-Verlag, NY. p. 1-122.

Livesey, J.C. and M.W. Anders. 1979. In vitro metabolism of 1,2-dihaloethane to ethylene. Drug. Metab. Dispos. 7: 199-203.

Livesey, J.C., M.W. Anders, P.W. Langvardt, C.L. Putzig and H.R. Reitz. 1982. Stereochemistry of the glutathione-dependent biotransformation of vicinal-dihaloalkanes to alkanes. Drug Metab. Dispos. 10: 201-204.

Lochhead, H.B. and H.P. Close. 1951. Ethylene dichloride plastic cement -- A case of fatal poisoning. JAMA. 146: 1323.

Logan, J.A., M.J. Prather, S.C. Wofsy and M.B. McElroy. 1981. Tropospheric Chemistry: A global perspective. J. Geophys. Res. 86: 7210-7254.

Lovelock, J.E. 1974. The electron capture detector: Theory and practice. J. Chromat. 99: 3-12.

Lowenheim, F. and M. Moran. 1975. Ethylene Dichloride. In: Faith, Keyes, and Clark's Industrial Chemicals, 4th ed., John Wiley and Sons, Inc., NY. p. 392-396.

Ludzack, F.J. and M.B. Ettinger. 1960. Chemical Structures resistant to aerobic biochemical stabilization. J. Water Pollut. Control Fed. 32: 1173-1200.

Lutz, W.K. 1979. In vivo covalent binding of organic chemicals to DNA as a quantitative indicator in the process of chemical carcinogenesis. Mutat. Res. 65: 289-356.

Luzhnikov, L.I. and A.S. Savina. 1976. Mycardiopathies in acute poisonings. Therapeuticheskii Arkhiv. 48(9): 84-88.

Luzhnikov, E.A., A.A. Andryukin, A.S. Savina., et al. 1974. To title provided. Therapeuticheskii Arkhiv. 46(2): 131-135.

Luzhnikov, E.A., L.I. Petrova, A.S. Savina, L.G. Kostomareva and A.V. Zakharova. 1978. Lesion of the heart in exotoxic shock. Kardiologiya. 18: 83-88. (Summarized in Chem. Abstr.).

Lyman, W.J., W.F. Reehe and D.H. Rosenblatt. 1982. Handbook of Chemical Property Estimation Methods. Environmental Behavior of Organic Compounds. McGraw-Hill Book Co., New York, NY. 960 p.

Mabey, W.B., J.H. Smith, R.T. Podoll, et al. 1981. Aquatic Fate Process Data for Organic Priority Pollutants. U.S. EPA, Monitoring and Data Support Division, Washington, DC. EPA-440/4-81-014.

Maltoni, C., L. Valgimigli and C. Scarnato. 1980. In: Banbury Report No. 5. Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds. Cold Spring Harbor Laboratory, p. 3-33.

Mantel, N. and M.A. Schneiderman. 1975. Estimating "safe" levels, a hazardous undertaking. Cancer Res. 35: 1379-1386.

Martin, G., K. Knorpp, K. Huth, F. Heinrich and C. Mittermayer. 1969. Clinical features, pathogenesis and management of dichlorethane poisoning. Ger. Med. Mon. 14: 62-67. (Summarized in NIOSH, 1976).

Martin, G., K. Knorpp, K. Huth, F. Henrich and D. Mittermayer. 1969. Clinical features, pathogenesis and management of dichloroethane poisoning. Ger. Med. Mon. 14: 62-67.

McCann, J., V. Simmon, D. Streitwieser and B.N. Ames. 1975. Mutagenicity of chloroacetaldehyde, a possible metabolic product of 1,2-dichloroethane (ethylene dichloride), chloroethanol (ethylene chlorohydrin), vinyl chloride, and cyclophosphamide. Proc. Natl. Acad. Sci. USA. 72(8): 3190-3193.

McCollister, D.D., R.L. Hollingsworth, F. Oyen and V.K. Rowe. 1956. Comparative inhalation toxicity of fumigant mixtures. AMA Arch. Ind. Health. 13: 1-7.

McConnell, G., D.M. Ferguson and C.R. Pearson. 1975. Chlorinated hydrocarbons and the environment. Endeavor. 34(121): 13-18.

McCormack, W.B., R. Moore and C.A. Sandy. 1981. Lead Compounds (organolead). In: Kirk-Othmer Encyclopedia of Chemical Technology, Third edition, Grayson, M. and Eckroth, D., eds. John Wiley and Sons, Inc., NY. Vol. 14, p. 186-189.

McKenna, M.J., J.A. Zempel, E.O. Madrid, W.H. Braun and P.J. Gehring. 1978. Metabolism and pharmacokinetic profile of vinylidene chloride in rats following oral administration. Toxicol. Appl. Pharmacol. 45: 821-835.

McNally, W.D. and G. Fostvedt. 1941. Ethylene Dichloride - Poisoning. Ind. Med. 10: 373-374.

McPherson, R.W., C.M. Starks and G.J. Fryar. 1979. Vinyl chloride monomer. What you should know. Hydrocarbon Processing. 3: 75-88

Melcher, R.G., R.R. Langner and R.O. Kagel. 1978. Criteria for the evaluation of methods for the collection of organic pollutants in air using solid sorbents. Am. Inc. Hyg. Assoc. 39(5): 349-361.

Menschick, H. 1957. Acute poisoning from inhalation of symmetrical dichloroethane. Arch. Gewerbepathol. Gewerbehyg. 15: 241-252. (Ger.) (Summarized in NIOSH, 1976).

Metcalf, R.L. 1981. Insect Control Technology. In: Kirk-Othmer Encyclopedia of Chemical Technology, Third edition, Grayson, M. and Eckroth, D., eds. John Wiley and Sons, Inc., NY. Vol. 13, p. 467.

Mill, T., W.R. Mabey, D.C. Bomberger, T.-W. Chon et al. 1982. Laboratory Protocols for Evaluating the Fate of Organic Chemicals in Air and Water. U.S. EPA Report No. EPA-600/3-82-022, Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA.

Miller, V., R.J. Dobbs and S.I. Jacobs. 1970. Ethylene chlorohydrin intoxication with fatality. Arch. Dis. Child. 45: 589-590.

Morgan, A., A. Black and D.R. Belcher. 1972. Studies on the absorption of halogenated hydrocarbons and their excretion in breath using <sup>38</sup>Cl tracer techniques. Ann. Occup. Hyg. 15: 273-282.

Morozov, G.N. 1958. On acute dichloroethane poisoning. Pharm. Toxicol. (USSR). 21: 80-83. (Summarized in NIOSH, 1976).

Mudder, T.I. 1982. Development of empirical structure biodegradability relationships and biodegradability testing protocol for volatile and slightly soluble priority pollutants. Presented at Div. Environ. Chem., Amer. Chem. Soc., Kansas City, MO. Sept. 1982. p. 52-53.

Munson, A.E., V.M. Sanders, K.A. Douglas, L.E. Sain, B.M. Kaufmann and K.L. White, Jr. 1982. In vivo assessment of immunotoxicity. EHP, Environ. Health Perspect. 43: 41-52.

Murray, J.S., K.S. Rao, J.T. Young et al. 1980. Ethylene dichloride: single generation inhalation reproduction study in rats. Unpublished study, Toxicology Research Laboratory, Dow Chemical U.S.A. Midland, MI.

Nachtomi, E. 1970. The metabolism of ethylene dibromide in the rat. The enzymatic reaction with glutathione in vivo, and in vitro. Biochem. Pharmacol. 19: 2853-2860.

Nachtomi, E., E. Alumot and A. Bondi. 1966. The metabolism of ethylene dibromide in the rat. I. Identification of detoxification products in urine. Isreal J. Chem. 4: 239-246.

Nakajima, T. and A. Sato. 1979. Enhanced activity of liver drug-metabolizing enzymes for aromatic and chlorinated hydrocarbons following food deprivation. Toxcol. Appl Pharmacol 50(3): 549-556.

NAS (National Academy of Science). 1978. Non-fluorinated halomethanes in the environment. Panel on low molecular weight-halogenated hydrocarbons on the coordinating committee for scientific and technical assessments of environmental pollutants.

National Science Foundation Panel on Manufactured Organic Chemicals in the Environment. 1975. SRI International Data.

NCI (National Cancer Institute). 1978. Bioassay of 1,2-dichloroethane for possible carcinogenicity. NCI carcinogenesis technical report series no. 55. Department of Health, Education, and Welfare Publication No. (NIH) 78-1361. Washington, DC: Government Printing Office.

NCI (National Cancer Institute). 1979. Bioassay of ethylene dibromide for possible carcinogenicity.

Neely, W.B. and J.H. Plonka. 1978. Estimation of time-average hydroxyl radical concentration in the troposphere. Environ. Sci. Technol. 12: 317-321.

Nestmann, E.R., E. Lee, T. Matula, G.R. Douglas and J. Mueller. 1980. Mutagenicity of constituents indentified in pulp and paper mill effluents using the Salmonella/mammalian-microsome assay. Mutat. Res. 79: 203-212.

NIOSH (National Institute for Occupational Safety and Health). 1974. Manual of analytical Methods, Health, Education, and Welfare Publication No. (NIOSH) 75-121.

NIOSH Technical Information. 1975. Collaborative Testing of Activated Charcoal Sampling Tubes for Seven Organic Solvents. Health, Education and Welfare Publication 75-184.

NIOSH. (National Institute for Occupational Safety and Health). 1976. Criteria for a Recommended Standard. Occupational Exposure to Ethylene Dichloride. U.S. Department of Health, Education, and Welfare. Superintendent of Doc., U.S. Government Printing Office, Washington, DC. 157 p.



Noetzel, O. 1944. Lethal poisoning with ethylene chloride. Chem. Z. 68: 146-147. (Ger.) (Summarized in NIOSH, 1976).

Noweir, M.H., E.A. Pfitzer and T.F. Hatch. 1972. Decomposition of chlorinated hydrocarbons; A review. J. Am. Ind. Hyg. Assoc. 33(7): 454-460.

Nylander, P.O., H. Olofsson and B. Rasmuson. 1979. The use of Drosophila melanogaster as a test for indirect mutagens. Mutat. Res. 64: 122-123.

Ohta, T., M. Morita and I. Mizoguchi. 1976. Local distribution of chlorinated hydrocarbons in the ambient air in Tokyo. Atmos. Environ. 10: 557-560.

Okuno, T., M. Tsiji, Y. Shintani and H. Watanabe. 1974. Gas chromatography of chlorinated hydrocarbons in urban air. Hyogo-ken Kogai Kenkyusho Kenyo Hokoku. 6: 106. (CA (1977), 87: 72564f).

Ollivier, H., P. Grillo-Abade, G. Helvadjian and J. Quicke. 1954. Report of a fatal case of intoxication by dichloroethane. Soc. Med. Leg. 34: 261-264. (Fr.) (Summarized in NIOSH, 1976).

Otterson, E.J. and C.U. Guy. 1964. A method of atmospheric solvent vapor sampling on activated charcoal in connection with gas chromatography. Trans. 26th Annual Meeting, Amer. Conf. of Governmental Industrial Hygienists, Philadelphia. p. 37-43.

Page, G.W. 1981. Comparison of groundwater and surface water for patterns and levels of contamination by toxic substances. Environ. Sci. Technol. 15: 1475-1481.

Page, B.D. and B.P.C. Kennedy. 1975. Determination of methylene chloride, ethylene dichloride, and trichloroethylene as solvent residues in spice oleoresins, using vacuum distillation and electron capture gas chromatography. J. Assoc. Off. Anal. Chem. 58(5): 1062-1068.

Paparopoli, G. and V. Cali. 1956. Collective intoxications with chlorinated hydrocarbons in dock workers. Folia. Med. (Napoli) 39: 819-831. (Ita.) (Summarized in NIOSH, 1976).

Patterson, R., M. Bornstein, R. Hall and E. Garshick. 1975. Assessment of Ethylene Dichloride as a Potential Air Pollution Problem, vol. III. Report number GCA-TR-75-32-G(3), GCA Corp., Bedford, MA. 25 p.

Pavlova, I.V., P.A. Rosenberg, N.K. Byalko and N.A. Gel'fon. 1965. Biochemical changes in the blood during acute intoxications by some chlorinated hydrocarbons. Prof. Zabol. V. Khim. Prom. p. 217-224. (Rus.) (Summarized in NIOSH, 1976).

Pearson, C.R. and G. McConnell. 1975. Chlorinated C<sub>1</sub> and C<sub>2</sub> hydrocarbons in the environment. Proc. R. Soc. Lond. B. 189: 305-332. marine

PEDCO Environmental Inc. 1979. Monitoring of ambient levels of ethylene dichloride (EDC) in the vicinity of EDC production and uses facilities. EPA, Contract No. 68-02-2722.

Pellizzari, E.D. 1974. Electron capture detection in gas chromatography. J. Chromat. 98: 323-361.

Pellizzari, E.D. 1977a. "The Measure of Carcinogenic Vapors in Ambient Atmospheres," NTIS PB-269582, EPA-600/7-77-055, prepared for U.S. Environmental Protection Agency by Research Triangle Institute, Research Triangle Park, NC.

Pellizzari, E.D. 1977b. "Analysis of Organic Air Pollutants by Gas Chromatograph and Mass Spectroscopy," Research Triangle Institute, Research Triangle Park, NC, EPA 600/2-77-100.

Pellizzari, E.D. 1978a. Preliminary assessment of halogenated organic compounds in man and environmental media. Monthly technical progress report No. 2 (January 1-30, 1978). Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract No. 68-01-4731.

Pellizzari, E.D. 1978b. Preliminary assessment of halogenated organic compounds in man and environmental media. Monthly technical progress report No. 5 (April 1-April 30, 1978). Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract No. 68-01-4731.

Pelizzari, E.D. 1978c. Preliminary assessment of halogenated organic compounds in man and environmental media. Monthly technical progress report No. 10 (September 1-30, 1978). Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract No. 68-01-4731.

Pellizzari, E.D. 1978d. Preliminary assessment of halogenated organic compounds in man and environmental media. Monthly technical progress report No. 11 (October 1-30, 1978). Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract No. 68-01-4731.

Pellizzari, E.D. 1978e. "Quantification of Chlorinated Hydrocarbons in Previously Collected Air Samples," Research Triangle Institute, Research Triangle Park, NC, EPA 450/3-78-112, NTIS PB 289804.

Pellizzari, E.D. 1978. Quantification of chlorinated hydrocarbons in previously collected air samples. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-450/3-78-112.

Pellizzari, E.D. 1978. Measurement of carcinogenic vapors in ambient atmospheres. EPA-600/7-78-062.

Pellizzari, E.D. 1979a. Information on the Characteristics of Ambient Organic Vapors in Areas of High Chemical Production. Prepared for U.S. EPA by Research Triangle Institute, Research Triangle Park, NC.

Pellizzari, E.D. 1979b. "Organic Screening in Lake Charles, LA, Using Gas Chromatography Mass Spectrometry Computer Techniques," EPA Contract 68-02-2714, Research Triangle Institute, Research Triangle Park, NC. (August).

Pellizzari, E.D. and J.E. Bunch. 1979. Ambient air carcinogenic vapors: Improved sampling and analytical techniques. Prepared by Research Triangle Institute for Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC. Contract No. 68-02-2764.

Pellizzari, E.D., M.D. Erickson and R.A. Zweidinger. 1979. Formulation of preliminary assessment of halogenated organic compounds in man and environmental media. U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-560/13-79-006.

Pellizzari, E.D., M.D. Erickson and R.A. Zweidinger. 1979. Formulation of a preliminary assessment of halogenated organic compounds in man and environmental media. U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC. U.S. EPA 560/13-79-006. NTIS PB 80-112170. Contract No. 68-014731.

Perocco, P. and G. Prodi. 1981. DNA damage by haloalkanes in human lymphocytes cultured in vitro. Cancer Letters. 13: 213-218.

Pervier, R., R. Barley, D. Field, B. Friedman, R. Morris and W. Schwartz. 1974. Survey Reports on Atmospheric Emissions From the Petrochemical Industry, Vol. II. Environmental Protection Agency, Contract No. 68-02-0255. Available from the National Technical Information Service, Springfield, VA., PB-244958, p. 135.

Piet, G.J., P. Slingerland, F.E. de Grund, M.P.M. v.d. Heuvel and B.C.J. Zoeteman. 1978. Determination of very volatile halogenated organic compounds in water by means of direct head-space analysis. *Anal. Lett.* 11(5): 437-448.

Plotnick, H.B., W.W. Weigel, D.E. Richards, K.L. Cheever and C. Kommirreni. 1980. Dietary disulfiram enhancement of the toxicity of ethylene dibromide. *In*: Banbury Report No. 5, Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds., Cold Spring Harbor Laboratory, p. 279-286.

Price, K., G. Waggy and R. Conway. 1974. Brine shrimp bioassay and seawater BOD (biochemical oxygen demand) of petrochemicals. *J. Water Pollution Control Fed.* 46(1): 63-77.

Rannug, U. 1976. Mutagenic studies of EDC tars as a model for tests of complex mixtures of chemicals in the environment. Nordforsk Miljøevardssekr. Publ. (2 Org. Miljøgifter Vaten, Nord. Symp. Vattenforsk, 12th) 561-565.

Rannug, U. 1980. Genotoxic effects of 1,2-dibromoethane and 1,2-dichloroethane. *Mutat. Res.* 76: 269-295.

Rannug, U. 1980. The use of different metabolizing systems in the elucidation of the mutagenic effects of ethylene dichloride in Salmonella. *In*: Banbury Report No. 5, Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds., Cold Spring Laboratory, p. 83-92.

Rannug, U. and C. Ramel. 1977. Mutagenicity of waste products from vinyl chloride industries. Journal of Toxicology and Environmental Health. 2: 1019-1029.

Rannug, U. and B. Beijs. 1979. The mutagenic effect of 1,2-dichloroethane on Salmonella typhimurium. II. Activation by the isolated perfused rat liver. Chemico-Biological Interactions. 24: 265-285.

Rannug, U., A. Sundvall and C. Ramel. 1978. The mutagenic effect of 1,2-dichloroethane on Salmonella typhimurium I. Activation through conjugation with glutathione in vitro. Chemico-Biological Interactions. 20: 1-16.

Rao, K.S., J.S. Murray, M.M. Deacon, J.A. John, L.L. Calhoun and J.T. Young. 1980. Teratogenicity and reproductive studies in animals inhaling ethylene dichloride. Bandury Report. 5: 149-166.

Reichert, D. and D. Henschler. 1978. Uptake and hepatotoxicity of 1,1-dichloroethylene by the isolated blood-perfused rat liver. Int. Arch. Occup. Environ. Health. 41: 169-178.

Reinfried, H. 1958. On lethal poisonings due to ingestion of 1,2-dichloroethane containing rubbing compounds. Deutsch. Gesundheitswes. 13: 778-779. (Ger.) (Summarized in NIOSH, 1976).

Reitz, R.H., T.R. Fox, J.Y. Domoradzki, J.F. Quast, P. Langvardt and P.G. Watanabe. 1980. In: Banbury Report No. 5, Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds., Cold Spring Harbor Laboratory, p. 135-148.

Reitz, R.H., T.R. Fox, J.C. Ramsey, J.F. Quast, P.W. Langvardt and P.G. Watanabe. 1982. Pharmacokinetics and micromolecular interactions of ethylene dichloride in rats after inhalation or gavage. *Toxicol. Appl. Pharmacol.* 62: 190-204.

Rejsek, K. and M. Rejskova. 1947. Intoxication with symmetrical dichloroethane. *Cas. Lek. Cesk.* 86: 207-209. (Cze.) (Summarized in NIOSH, 1976).

Rohmann, E., D. Zinn and J. Kulz. 1976. Electroencephalographic observations in childhood poisonings and their therapeutic consequences. *Kinderaeztl. Prax.* 37: 209-216. (Ger.) (Summarized in NIOSH, 1976).

Rosenbaum, N. 1939. Use of dichloroethane in industry from the standpoint of occupational hygiene, in [Dichloroethane]. Moskow, Chap. IV, p. 109-113. (Rus.) (Summarized in NIOSH, 1976).

Rosenbaum, N.D. 1947. Ethylene dichloride as an industrial poison. *Gig. Sanit.* 12(2): 17-21. (Rus.) (Summarized from English Translation).

Roubal, J. 1947. Two fatal cases of intoxication with symmetric dichloroethane ingestion. *Cas. Lek. Cesk.* 86: 203-206. (Cze.) (Summarized from NIOSH, 1976).



Salmon, A.G., W.C. Mackrodt, R.B. Jones, S.K. Basu and J. Ashby. 1978. An investigation of the dichlorination of a series of haloalkanes by rat liver microsomes and its possible role in the expression of toxic phenomenon. *Toxicol. Appl. Pharmacol.* 45(1): Abst. 253, 277.

Salvini, M. and B. Mazzucchelli. 1958. Intoxication from fumes of carbon tetrachloride and dichloroethane used as fumigant parasitocides. *Minerva. Med.* 49: 2295-2304. (Ita.) (Summarized from NIOSH, 1976).

Sato, A. and T. Nakajima. 1979. A structure-activity relationship of some chlorinated hydrocarbons. *Arch. Environ. Health.* 34(2): 69-75.

Sato, A., T. Nakajima and Y. Koyama. 1980. Effects of chronic ethanol consumption on hepatic metabolism of aromatic and chlorinated hydrocarbons in rats. *Br. J. Ind. Med.* 37: 382-386.

Sato, A., T. Nakajima and Y. Koyama. 1981. Dose-related effects of a single dose of ethanol on the metabolism in rat liver of some aromatic and chlorinated hydrocarbons. *Toxicol. Appl. Pharmacol.* 60: 8-15.

Schlachter, M.M, A.A. Crawford, J.A. John et al. 1979. The effects of inhaled ethylene dichloride on embryonal and fetal development in rats and rabbits. Unpublished study, Toxicology Research Laboratory, Dow Chemical U.S.A. Midland, MI.

Schoborn, H., W. Prellwitz and P. Baum. 1970. Consumption coagulation pathology of 1,2-dichloroethane poisoning. Klin. Wochenschr. 48: 822-824. (Ger.) (Summarized from NIOSH, 1976).

Schwartz, W.A., F.G. Higgins, Jr., J.A. Lee, R. Newirth and J.W. Pervier. 1974. Engineering and Cost Study of Air Pollution Control for the Petrochemical Industry. vol. 3. Ethylene Dichloride Manufacture by Oxychlorination. EPA-450/3-73-006c. Houdry Division, Air Products and Chemicals, Inc. Report prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC.

Secchi, G.C., G. Chiappino, A. Lotto and N. Zurlo. 1968. Actual chemical composition of the "commercial trieline" and their hepatotoxic effect - Clinical and enzymological studies. Med. Lav. 59: 486-497. (Ita.) (Summarized in NIOSH, 1976).

Seufert, F.B., P. Brown, J.A. Oatway, M. Bornstein, W. Ostrowski and R. Horne. 1980. 1,2-Dichloroethane: Technical control options analysis. Prepared by CGA Corp., Bedford, MA, for U.S. Environmental Protection Agency. Control No. 68-01-5960 as cited in Letkiewicz et al., 1982.

Shackelford, W.M. and L.H. Keith. 1976. Frequency of Organic Compounds Identified in Water. EPA-600/4-76-062. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA. p. 134.

Shakarnis, V.F. 1969. Induction of X-chromosome nondisjunction and recessive sex-linked recessive lethal mutations in females of Drosophila melanogaster by 1,2-dichloroethane. Sov. Genetics. 5: 1666-1671.

Shakarnis, V.F. 1970. Effect of 1,2-dichloroethane. Vesnik Leningradskunivsiteta Seviya Biologii. 25(1): 153-156.

Shamel, R.E., R. Williams, J.K. O'Neill, R. Eller, R. Green, K.D. Hallock and R.P. Tschirch. 1975. Preliminary Economic Impact Assessment of Possible Regulatory Action to Control Atmospheric Emissions of Selected Halocarbons. EPA-450/3-75-073. Arthur D. Little, Inc., Cambridge, MS, Report prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC.

Shchepotin, B.M. and Ya. D. Bondarenko. 1978. Clinical syndromes and pathogenic treatment principles of dichloroethane intoxications. Vrach. Delo. 7: 134-139.

Siegel, I.M. 1947. Ethylene dichloride. JAMA. (Lett). 133: 577.

Simmon, V.F. 1980. Review of nonbacterial tests of the genotoxic activity of ethylene dichloride. In: Banbury Report 5. Ethylene dichloride: A potential health risk? B.N. Ames, P. Infante and R. Reitz, eds. Cold Spring Harbor Laboratory Press. Cold Spring Harbor, NY. p. 97-103.

Singh, H.B. 1977. Atmospheric halocarbons. 1977. Evidence of favor of reduced average hydroxyl radical concentrations in the troposphere. Geophy. Res. Lett. 4(3): 101-104.

Singh, H.B. 1978. Letter to the editor. Atmos. Environ. 12: 1809.

Singh, H.B., L. Salas, D. Lillian, R.R. Arnts and A. Appleby. 1977. Generation of accurate halocarbon primary standards with permeation tubes. Environ. Sci. Technol. 11(5): 511-513.

Singh, H.B., L.J. Salas, H. Shigeishi, A.J. Smith, E. Schibner and L.A. Cavanagh. 1979. Atmospheric distributions, sources and sinks of selected halocarbons, hydrocarbons, SF<sub>6</sub> and NO<sub>2</sub>. Grant No. 8038020. EPA-600/3-79-107.

Singh, H.B., L.J. Salas, A. Smith and H. Shigeishi. 1980. Atmospheric measurements of selected toxic organic chemicals - interim report 1979. Grant No. 805990. EPA-600/3-80-072.

Singh, H.B., L.J. Salas, A. Smith and P. Shigeshi. 1980. Atmospheric measurements of selected toxic organic chemicals: Halogenated alkanes, chlorinated aromatics, aromatic hydrocarbons and secondary organics. Prepared by SRI International for Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC. Interim report. SRI Project 7774.

Singh, H.B., L.J. Salas, A.J. Smith and H. Shigeishi. 1981. Measurements of some potentially hazardous organic chemicals in urban environments. Atmos. Environ. 15(4): 601-612.

Singh, H.B., L.J. Salas and R.E. Stiles. 1982. Distribution of Selected Gaseous Organic Mutagens and Suspect Carcinogens in Ambient Air. Environ. Sci. Technol. 16(12): 872.

Singh, H.B., L.T. Salas and R.E. Stiles. 1983. Selected man-made halogenated chemicals in the air and oceanic environment. J. Geophys. Res. 88: 3675-3683.

Singh, H.B., L.J. Salas, R. Stiles and H. Shigeishi. 1983. Measurements of Hazardous Organic Chemicals in the Ambient Atmosphere. Grant No. CA 805990. U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC. EPA-600/3-83-002, Avail. NTIS, PB-83 156935.

Sipes, I.G. and A.J. Gandolfi. 1980. In vitro comparative bioactivation of aliphatic halogenated hydrocarbons. Dev. Toxicol. Environ. Sci. 8: 501-506.

Sjoberg, B. 1952. Thermal decomposition of chlorinated hydrocarbons. Svensk Kem. Tidskr. 64: 63.

Smirnova, N.A. and H.P. Granik. 1970. On the remote effects of acute occupational poisoning with some carbohydrates and their derivatives. Gig. Tr. Prof. Zabol. 14(5): 50-51. (Rus.) (Summarized in NIOSH, 1976).

Smyth, H.F., Jr. 1956. In: Handbook of Toxicology, Vol. I., W.S. Spector, ed.

Snapp, O.I. 1958. Trunk sprays for control of the peach tree borer. J. Econ. Entomol. 51(4): 557-558.

Snelson, A., R. Butler and F. Jarke. 1978. Study of removal processes for halogenated air pollutants. EPA-600/3-78-058, Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC.

Sopikov, N.F. and A.K. Gorshunova. 1979. Investigation of the uptake, distribution, and excretion of ethylene dichloride in rats. Gig. Tr. Prof. Zabol. 4: 36-40.

Spence, J.W. and P.L. Hanst. 1978. Oxidation of chlorinated ethanes. J. Air. Pollut. Control Assoc. 28(3): 250-255.

Spencer, H.C., V.K. Rowe, E.M. Adams, D.D. McCollister and D.D. Irish. 1951. Vapor toxicity of ethylene dichloride determined by experiments on laboratory animals. Industrial Hygiene and Occupational Medicine. 4: 482.

Spreafico, F., E. Zuccato, F. Murcurei et al. 1978. Metabolism of 1,2-dichloroethane in experimental animals, Report Nos. 1 and 2 to Chemical Manufacturers Association, New York, NY.

Spreafico, F., E. Zuccato, F. Murcurci et al. 1979. Distribution and metabolism of 1,2-dichloroethane (EDC) in experimental animals. Report Nos. 3 and 4 to Chemical Manufacturers Association, New York, NY.

Spreatico, F., E. Zuccato, F. Murcurei et al. Pharmacokinetics of ethylene dichloride in rats treated by different routes and its long-term inhalatory toxicity. In: Banbury Report No. 5, Ethylene dichloride: A potential health risk? B. Ames, P. Infante and R. Reitz, eds., Cold Spring Harbor Laboratory, p. 107-133.

SRI International. 1979. Population exposure to EDC. Menlo Park, CA: SRI International. U.S. EPA Contract No. 68-02-2835, as cited in memorandum from David R. Patrick to Lester Grant, U.S. EPA, Research Triangle Park, NC, December 14, 1982.

SRI International. 1983. 1983 Directory of Chemical Producers: United States of America. SRI International, Menlo Park, CA. p. 584, 771, 949, 965, 583.

SRI (Stanford Research Institute). 1981. National Screening Program for Organics in Drinking Water. Boland, PA: SRI International. EPA Contract No. 68-01-4666.

Stoelting, R.K. and E.I. Eger. II. Percutaneous loss of nitrous oxide, cyclopropane, ether, and haloethane in man. Anesthesiology. 30: 278-283.

Stolzenberg, S.J. and C.H. Hine. 1980. Mutagenicity of 2- and 3-carbon halogenated compounds in the Salmonella/mammalian-microsome test. Environmental Mutagenesis. 2: 59-66.

Storer, R.D., T.A. Bank and R.D. Conolly. 1982. In vivo genotoxic effect of 1,2-dichloroethane in male B6C3F1 mice. Toxicologist. 2: 129.

Storey, C.L., L.D. Krik and G.C. Mustakas. Fate of EDC-CCl<sub>4</sub> (75:25) residues during milling and oil extraction of soybeans. J. Econ. Entomol. 65(4): 1126-1129.

Stover, E.L. and D.F. Kincannon. 1983. Biological treatability of specific organic compounds found in chemical industry wastewater. J. Water. Pollut. Control. Fed. 55: 97-109.

Stuhlert, H. 1949. Fatal poisoning from ethylene chloride. Dtsch. Med. Wochenschr. 74: 1542-1543. (Ger.) (Summarized in NIOSH, 1976).

Suta, B.E. 1979. Assessment of human exposures to ethylene dichloride. Prepared by SRI International for Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, under Contract No. 68-02-2835, Task 17. Final Report.

Suveev, I.M. and M.E. Babichenko. 1969. Clinical picture and treatment of acute poisoning with dichloroethane vapors. Gig. Tr. Prof. Zabol. 13(1): 50-51. (Rus.) (Summarized in NIOSH, 1976).

Sykes, J.F. and A.F. Klein. 1957. Chloro-organic residues in milk of cows orally administered ethylene dichloride. J. Assoc. Off. Agric. Chem. 40: 203-209.

Sykes, J.F. and A.K. Klein. 1957. Participating Chemists. Chloro-organic residues in milk of cows orally administered ethylene dichloride. Assoc. Off. Agric. Chem. 40(1): 206-209.



Sykes, J.F. and A.K. Klein. 1957. Fumigant residue-in-milk study. Chloro-organic residues in milk of cows orally administered ethylene dichloride. Assoc. Off. Agric. Chem. 40(1): 203-206.

Symons, J.M., T.A. Bellar, J.K. Carswel, et al. 1975. National organics reconnaissance survey for halogenated organics. J. Am. Water Works Assoc. 67(11): 634-647.

Tan, E.L. and A.W. Hsie. 1981. Mutagenicity and cytotoxicity of haloethanes as studied in the CHO/HGPRT system. Mutat. Res. 90: 183-191.

Tabak, H.H., S.A. Quave, C.I. Mashni and E.F. Barth. 1981. Biodegradability studies with organic priority pollutant compounds. J. Water Pollut. Control Fed. 53: 1503-1518.

Theiss, J., G. Stoner, M. Schimkin and E.I. Weisburger. 1977. Test for carcinogenicity of organic contaminants of United States drinking water by pulmonary tumor response in Strain A mice. Cancer Res. 37: 2717-2720.

Troisi, F.M. and D. Cavallazzi. 1961. Fatal poisoning from the inhalation of dichloroethane fumes. Med. Lav. 52: 612-618. (Ita.) (Summarized in NIOSH, 1976).

Tsuruta, H. 1975. Percutaneous absorption of organic solvents. 1. Comparative study of the in vivo percutaneous absorption of chlorinated solvents in mice. Ind. Health. 13(4): 27-236.

Tsuruta, H. 1977. Percutaneous absorption of organic solvents. 2. A method for measuring the penetration rate of chlorinated solvents through excised rat skin. Ind. Health. 15: 3-4, 131-139.

Urusova, T.P. 1953. The possible presence of dichloroethane in human milk with exposure in industrial conditions. Gig. Sanit. 18: 36-37.

U.S. EPA. n.d. A Study of Industrial Data on Candidate Chemicals for Testing. EPA-560/5-77-006. SRI International, Menlo Park, CA.

U.S. EPA. n.d. Determination of Population Density Around Ethylene Dichloride Production Facilities. EPA Contract Numer 68-02-2836.

U.S. EPA. 1977. National Organics Monitoring Survey. Office of Water Supply, as cited in Letkiewicz et al., 1982.

U.S. EPA. 1979. Health Assessment Document for 1,2-Dichloroethane (Ethylene Dichloride). Draft report prepared by the Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC.

U.S. EPA. 1979. Monitoring of ambient levels of ethylene dichloride (EDC) in the vicinity of EDC production and user facilities. EPA-600/4-79-029. Environment Monitoring and Support Laboratory, Research Triangle Park, NC. 131 p.

U.S. EPA. 1979. Monitoring of Ambient Levels of EDC Near Production and User Facilities. EPA-600/4-79-029. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Research Triangle Park, NC. 131 p.

U.S. EPA. 1979a. Population Exposure to EDC. Draft report. SRI International, Menlo Park, CA. Contract Number 68-02-2835.

U.S. EPA. 1979b. Investigations of Selected Environmental Pollutants: 1,2-Dichloroethane. EPA 560/2-78-006.

U.S. EPA. 1981a. Community Water Supply Survey. Office of Drinking Water, as cited in Letkiewicz et al., 1982.

U.S. EPA. 1981b. Draft criteria document for 1,2-dichloroethane. U.S. Environmental Protection Agency, Office of Drinking Water, Washington, DC., as cited in Letkiewicz et al., 1982.

U.S. EPA. 1981. The determination of halogenated chemical indicators of industrial contamination in water by the purge-and-trap method, method 502.1. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA 600/4-81-059.

U.S. EPA. 1982a. Handbook for sampling and sample preservation of water and wastewater. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA 600/4-82-029.

U.S. EPA. 1982b. Test methods for evaluating solid waste, physical/chemical methods. Office of Solid Waste and Emergency Responses, U.S. Environmental Protection Agency, Washington, DC. SW-846.

U.S. EPA. 1982c. Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater. J.E. Longbottom and J.J. Lichtenburg, eds. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH. EPA-600/4-82-057.

U.S. EPA. 1982. Groundwater Supply Survey, as cited in Letkiewicz et al., 1982.

USITC (International Trade Commission). 1975-1983. Synthetic Organic Chemicals. U.S. Production and Sales, U.S. International Trade Commission.

USITC (International Trade Commission). 1977. Synthetic Organic Chemicals. USITC Publication Number 20.

USTC (Tariff Commission). 1952-1974. Synthetic Organic Chemicals. U.S. Production and Sales. United States Tariff Commission.

Valvani, S.C., S.H. Yalkowsky and T.J. Roseman. 1981. Solubility and partitioning. IV. Aqueous solubility and octanol-water partition coefficients of liquid nonelectrolytes. J. Pharm. Sci. 70(5): 502-507.

Van Duuren, B., B. Goldschmidt, G. Loewengart et al. 1979. Carcinogenicity of halogenated olefinic and aliphatic hydrocarbons in mice. J. Natl. Cancer Inst. 63: 1433-1439.

Van Dyke, R. and C. Wineman. 1971. Enzymatic dechlorination. Dechlorination of chloroethane and propanes in vitro. Biochem. Pharmacol. 20: 463-470.

Vesar, Inc. 1975. Identification of Organic Compounds in Effluents from Industrial Sources. Final Report to EPA Office of Toxic Substances, Washington, DC, EPA-560/3-75-002.

Vincent, L.E. and D.L. Lindgren. 1965. Influence of fumigation and age on carbon dioxide production of some stored-product insects. J. Econ. Entomol. 58(4): 660-664.

Von Oettinger, W.F. 1964. The Halogenated Hydrocarbons of Industrial and Toxicological Importance. Elsevier, Amsterdam, London, New York.

Vozovaya, M. 1971. Changes in the esterase cycle of white rats chronically exposed to the combined action of gasoline and dichloroethane vapors. Akush. Genekol. (Kiev). 47(12): 65-66.

Vozovaya, M. 1975. The effect of low concentrations of benzene dichloroethane alone and their combination on the reproductive function of animals and on the development of progeny. Gig. Tr. Prof. Zabol. 7: 20-23.

Vozovaya, M. 1975. The effect of low concentrations of benzene, dichloroethane, alone and their combination on the reproductive function animals and on the development of progeny. Gig. Tr. Prof. Zabol. 7: 20-23

Vozovaya, M. 1976. Effect of low concentrations of benzene and dichloroethane separately and combined on the reproductive function animals. Gig. Sanit. 6: 100-102.

Vozovaya, M. 1977. The effect of dichloroethane on the sexual cycle and embryogenesis of experimental animals 1977. Akusk. Ginekol. (Moscow). 2: 57-59.

Wadhi, S.R. and T. Soares. 1964. Comparative toxicity of some fumigants to the Red Scale, Aonidrella aurantii (Maskell) (Hemiptera: coccioidea). Indian J. Entomol. 27: 85-88.

Wallace, L. 1981. "Measurements of Volatile Organic Compounds in Breathing Zone Air, Drinking Water and Exhaled Breath (Preliminary Draft). Cited in Brodzinsky and Singh, 1982.

Ward, J. 1980. Pages 35-54 in B. Ames, P. Infante and R. Reitz, Eds. Banbury Report No. 5. Ethylene dichloride: A potential health risk. Cold Spring Harbor Laboratory.

Watrous, R.M. 1947. Health hazards of the pharmaceutical industry. Br. J. Inc. Med. 4: 111-125.

Weast, R.C. 1980. Handbook of Chemistry and Physics, Sixty-First edition. CRC Press Inc., Boca Raton, FL. p. C-309.

Weisburger, E. 1977. Carcinogenicity studies on halogenated hydrocarbons. Environ. Health Perspect. 21: 7-16.

Weiss, F. 1957. Lethal oral poisoning from dichloroethane. Arch. Gewerbe-pathol. Gewerbahyg. 15: 253-264. (Ger.) (Summarized in NIOSH, 1976).

Wendel, H. 1948. Lethal poisoning from dichloroethane (ethylene chloride). Pharmazie. 3: 398-400. (Ger.) (Summarized in NIOSH, 1976).

Whitney, W. 1961. Fumigation hazards as related to the physical, chemical, and biological properties of fumigants. Pest. Control. 29(7): 16-21.

Whittemore, A. 1978. Quantitative theories of carcinogenesis. In: Advances in cancer research. Vol. 27. Academic Press, New York, NY. p. 55-58.

Whittemore, A. and B. Keller. 1978. Quantitative theory of carcinogenesis. Society for Industrial and Applied Mathematics Review. 20: 1-30.

Williams, R.T. 1959. Detoxication mechanisms. London. p. 55.

Wilson, J.T., C.G. Enfield, W.J. Dunlap, R.L. Cosby, D.A. Foster and L.B. Baskin. 1981. Transport and fate of selected organic pollutants in a sandy soil. J. Environ. Qual. 10(4): 501-506.

Wirtschafter, Z.T. and E.D. Schwartz. 1939. Acute ethylene dichloride poisoning. J. Ind. Hyg. Toxicol. 21: 126-131.

Withey, J.R. and B.T. Collins. 1980. Chlorinated aliphatic hydrocarbons used in the food industry: The comparative pharmacokinetics of methylene chloride, 1,2-dichloroethane, chloroform and trichloroethylene after i.v. administration in the rat. J. Environ. Pathol. Toxicol. 3: 313-332.

Withey, J.R., B.T. Collins and P.G. Collins. 1982. Effect of vehicle on the pharmacokinetics and uptake of four halogenated hydrocarbons from the gastrointestinal tract of the rat. Pre-print paper submitted to J. Appl. Toxicol. December, 1982.

Woodward, G., S. Lange, K. Nelson and H. Calvery. 1981. The acute oral toxicity of acetic, chloroacetic, dichloroacetic and trichloroacetic acids. J. Ind. Hyg. Toxicol. 23: 78-82.

Yasoda, S.K. and E. Dan Loughran. 1977. Air sampling methods for S-tetrachloroethane and other related chlorinated hydrocarbons. J. Chromat. 137-283-292.

Yllner, S. 1971a. Metabolism of chloroacetate-1-<sup>14</sup>C in the mouse. Acta. Pharmacol. Toxicol. 30: 69-80/

Yllner, S. 1971b. Metabolism of 1,2-dichloroethane-<sup>14</sup>C in the mouse. Acta. Pharmacol. Toxicol. 30: 257-265.

Yllner, S. n.d. Chlorinated aliphatic hydrocarbons used in the foods industry. The comparative pharmacokinetics of methylene chloride, 1,2-dichloroethane, chloroform, and trichloroethylene after I.V. administration in the rat. J. Environ. Pathol. Toxicol. 3: (in press).



# APPENDIX A

## COMPARISON AMONG DIFFERENT EXTRAPOLATION MODELS

Four models used for low-dose extrapolation, assuming the independent background, are:

Multistage: 
$$P(d) = 1 - \exp [-(q_1 d + \dots + q_k d^k)]$$

where  $q_i$  are non-negative parameters;

Probit: 
$$P(d) = \frac{A + B \ln(d)}{\int_{-\infty}^{\infty} F(x) dx}$$

where  $f(\cdot)$  is the standard normal probability density function;

Weibull: 
$$P(d) = 1 - \exp [-bd^k]$$

where  $b$  and  $k$  are non-negative parameters; and

One-hit: 
$$P(d) = 1 - \exp [-bd]$$

where  $b$  is a non-negative parameter.

The maximum likelihood estimates (MLE) of the parameters in the multistage and one-hit models are calculated by means of the program GLOBAL82, which was developed by Howe and Crump (1982). The MLE estimates of the parameters in the probit and Weibull models are calculated by means of the program RISK81, which was developed by Kovar and Krewski (1981).

Table A-1 presents the MLE of parameters in each of the four models that are applicable to a data set.

TABLE A-1. MAXIMUM LIKELIHOOD ESTIMATES OF THE PARAMETERS FOR EACH OF THE FOUR  
EXTRAPOLATION MODELS BASED ON DIFFERENT DATA BASES

Data base	Multistage	Probit	Weibull	One-hit
Hemangiosarcomas in male rats, dose with surface correction	$q_1 = 3.65 \times 10^{-2}$ $q_2 = 0$	$A = -1.43$ $B = 0.34$	$b = 9.08 \times 10^{-2}$ $k = 0.52$	$b = 3.65 \times 10^{-2}$
A-2 Hemangiosarcomas in male rats, dose without surface correction	$q_1 = 7.03 \times 10^{-3}$ $q_2 = 0$	$A = -1.99$ $B = 0.34$	$b = 3.84 \times 10^{-2}$ $k = 0.52$	$b = 7.03 \times 10^{-3}$
Hepatocellular carcinomas in male mice, dose with surface correction	$q_1 = 1.03 \times 10^{-2}$ $q_2 = 1.47 \times 10^{-3}$	$A = -2.75$ $B = 0.86$	$b = 8.07 \times 10^{-3}$ $k = 1.49$	$b = 2.32 \times 10^{-2}$
Heptocellular carcinomas in male mice, dose without surface corrections	$q_1 = 8.18 \times 10^{-4}$ $q_2 = 9.25 \times 10^{-6}$	$A = -4.92$ $B = 0.86$	$b = 1.84 \times 10^{-4}$ $k = 1.49$	$b = 3.04 \times 10^{-3}$

## APPENDIX B

### RISK CALCULATION BASED ON TIME-TO-EVENT DATA

Because of the high mortality rate of rats in the high-dose group of the NCI (1978) gavage study, it is more appropriate to use time-to-event data (Table B-1) to calculate the potency of EDC. The probability of cancer by time  $t$  at dose  $d$  is given by:

$$P(d,t) = 1 - \exp [-f(t) \times g(d)]$$

where  $g(d)$  is a polynomial in dose  $d$ , and  $f(t)$  is a function of time  $t$ . The maximum likelihood estimate of the parameters and the asymptotic properties of the incremental risk estimate were investigated by Daffer et al. (1980). Their approach to estimating the parameters resembles Cox's regression-life-table approach (Cox 1972), in which the time function  $f(t)$  need not be specified.

Using the data in Table B-1, the lifetime cancer risk is estimated to be

$$q_1^* = 6.9 \times 10^{-2} \text{ mg/kg/day}$$

This value is the 95% upper bound of the risk calculated at  $t = 90$  weeks. Since the model fits the data very well up to 90 weeks but poorly beyond 90 weeks (overestimates),  $P(d, 90)$  is used to approximate the lifetime risk. This seems reasonable because the median lifespan for control animals is also less than 90 weeks (approximately 70% of the control animals died before 90 weeks).

TABLE B-1. TIME-TO-DEATH IN WEEKS FROM HEMANGIOSARCOMAS  
IN MALE OSBORNE-MENDEL RATS FED EDC BY GAVAGE

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Control (vehicle and untreated):

28, 37, 50, 50, 53, 53, 53, 54, 57, 57, 57, 57, 57, 61, 61,  
69, 71, 76, 78, 80, 80, 83, 85, 86, 87, 89, 90, 101, 101,  
104, 106, 106, 106, 106, 106, 108, 110, 110, 110, 110.

Low-dose group:

30, 34, 36, 51, 52, 52, 55, 55, 59, 61, 63, 65, 69, 73(H)<sup>a</sup>,  
74(H), 75, 75, 76, 77, 77, 77(H), 77, 80, 81, 82, 82, 82, 84,  
87(H), 89(H), 89, 89, 89, 90, 92, 92, 93(H), 95(H), 96, 97,  
98, 99, 99, 102(H), 103, 103, 104, 104, 109(H), 110.

High-dose group:

3, 8, 9, 9, 10, 10, 10, 10, 10, 11, 15, 15, 16, 20, 22, 33,  
33, 33, 34, 37, 41, 48, 51, 52, 54, 57, 58, 59, 60, 61(H),  
62, 63, 63, 68(H), 68(H), 71, 72, 73, 74, 74(H), 74, 74, 76(H),  
76, 78(H), 83(H), 84, 89, 101.

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<sup>a</sup>H indicates death from hemangiosarcoma.

## APPENDIX C

### CALCULATION OF EDB CARCINOGENIC POTENCIES BY GAVAGE AND INHALATION ROUTES

The data used for calculating the potency of EDB by gavage are presented in Table C-1. The data from the high-dose group are not used because the dose pattern from the high-dose group was drastically modified during the experiment, resulting in a time-weighted dose almost identical to that of the low-dose group. Using the life-table approach (Kaplan and Meier 1958), the probability of cancer at week 49 (the end of the study) is 0.37 with the 95% one-sided upper-confidence limit at 0.46. Thus, the upper-bound estimate of the slope in the one-hit model,  $P = 1 - \exp(-bd)$ , is:

$$\begin{aligned} b &= [-\ln(1-P)]/d \\ &= [-\ln(1-0.46)]/5.01 \\ &= 0.12 \text{ mg/kg/day.} \end{aligned}$$

The lifetime cancer potency, adjusting for the less-than-lifetime study, is

$$B = 0.12 \times (90/49)^3 = 0.74 \text{ mg/kg/day}$$

where 90 weeks is the lifespan that is also used in the EDC calculation when time-to-event data are used.

Therefore, EDB is approximately 10 times more potent than EDC (i.e.,  $0.74/0.069$ ).

The data used for calculating the potency of EDB by inhalation are presented in Table C-2. The carcinogenic potency of EDB by inhalation is calculated on the basis of nasal cavity tumors in male rats from the NCI inhalation study on EDB (NCI 1979), using the linearized multistage model. The potency of EDB by inhalation is

$$6.77 \times 10^{-5}/(\text{ug}/\text{m}^3).$$

TABLE C-1. TIME-TO-DEATH IN WEEKS FROM HEMANGIOSARCOMAS  
IN MALE OSBORNE-MENDEL RATS FED EDB BY GAVAGE  
(NCI 1978)

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Low-dose group (38 mg/kg/day)<sup>a</sup>

31(H)<sup>b</sup>, 32, 34(H), 34(H), 35, 36, 37, 38(H), 39, 39, 40, 41,  
42, 43, 43, 43, 43, 43, 43, 44, 44, 44, 46, 46, 47, 47, 48(H),  
48, 48, 48, 48, 49(H), 49(H), 49(H), 49(H), 49(H), 49(H), 49,  
49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49, 49.

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<sup>a</sup>The animals were fed EDB 5 days per week for 47 weeks (out of 49 weeks observation period). The human equivalent dose is  $(38 \text{ mg/kg/day}) \times (5/7) \times (47/49) \times (0.5/70)^{1/3} = 5.01 \text{ mg/kg/day}$ .

<sup>b</sup>H indicates that the animals died from hemangiosarcomas. It is assumed that all animals observed with tumors at week 49 died from the tumors. This assumption seems reasonable, since the time from exposure to tumor death was very short.

TABLE C-2. INCIDENCE OF NASAL CAVITY TUMORS IN MALE  
FISCHER 344 RATS ADMINISTERED EDB BY INHALATION  
(NCI 1979)

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Human equivalent dose ( $\text{ug}/\text{m}^3$ ) <sup>a</sup>	Animal dose (ppm)	Response
0	0	0/50 (0%)
$1.39 \times 10^4$	10	39/50 (78%)
$5.57 \times 10^4$	40	41/50 (82%)

---

<sup>a</sup>Human equivalent dose =  $d \times (5/7) \times (6/24) = 0.178 \times d$ . The dose is converted to the unit of  $\text{ug}/\text{m}^3$  by using  $1 \text{ ppm} = 7.83 \times 10^3 \text{ ug}/\text{m}^3$ .