IMPACTS OF CHLORINE USE ON ENVIRONMENTAL AND PUBLIC HEALTH

(A Science Report To Governor John Engler)

Prepared by
Michigan Environmental Science Board
Chlorine Panel

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JUNE 1994

(FIRST PRINTING)

PREFACE

Michigan Environmental Science Board

The Michigan Environmental Science Board (MESB) was created by Governor John Engler by Executive Order 1992-19 on August 6, 1992. The MESB is charged with advising the Governor, the Natural Resources Commission, the Michigan Department of Natural Resources and other state agencies, as directed by the Governor, on matters affecting the protection and management of Michigan's environment and natural resources. The MESB consists of 9 individuals and an executive director, appointed by the Governor, who have expertise in one or more of the following areas: engineering, ecological sciences, economics, chemistry, physics, biological sciences, human medicine, statistics, risk assessment, geology and other disciplines as necessary. Upon the request of the Governor to review a particular issue, a panel, consisting of MESB members with relevant expertise, is convened to evaluate and provide recommendations on the issue.

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MAJOR FINDINGS AND CONCLUSIONS

The International Joint Commission's (IJC) Seventh Biennial Report on Great Lakes Water Quality, released less than three months ago, recommended that the governments of Canada and the United States "*...consult with industry and other interests to develop timetables to sunset the use of chlorine and chlorine-containing compounds as industrial feedstocks and examine the means of reducing and eliminating other uses, recognizing that socio-economic considerations must be taken into account in developing the strategies and timetables*". This statement, when considered alone does not appear to be as inflammatory as the issue has become at this time. The controversy surrounding the proposal for regulatory elimination (sunsetting) of chlorine use has been heightened by the language used within the debate and the vagueness of the above statement. Those in support of the sunsetting of chlorine have often used as examples the toxic effects of known, environmentally persistent, bioaccumulative chlorinated compounds. An undefined timetable and an inability to know which chlorine-containing compounds and their uses are involved in the proposed ban provide fertile ground for the imaginations of proponents and antagonists. These factors and the vast economic resources involved in chlorine use have fueled much concern and discussion.

On November 18, 1993, the Michigan Environmental Science Board (MESB) was charged by Governor John Engler to evaluate the scientific basis for the IJC's recommendations on chlorine and chlorinated compounds and to evaluate whether Michigan's body of regulations affecting the use of chlorine and chlorinated compounds adequately protect Michigan's citizens' health, its environment and its Great Lakes.

A Panel, composed of six MESB members, was convened on November 30, 1993 to begin the project. The investigation consisted of the accumulation and evaluation of peer-reviewed and some non-peer-reviewed literature and data on the subject. In addition, verbal and written statements from experts, industry specialists, environmental organizations, state governmental agencies and concerned citizens were considered. Major findings and conclusions of the MESB Chlorine Panel are summarized below.

- The known toxicity of certain chlorinated compounds, particularly those exhibiting persistence, and the possibility that *unknown* products of similar toxic potential are now reaching the environment, or may do so in the future, makes it necessary to evaluate current and future uses of chlorine and chlorinated compounds. Discussions, similar to those called for by the IJC, should take place among industry, government and public interest groups to examine the risks and benefits of the chlorinated products in use. Included in these discussions should be the consideration of safety and effectiveness of possible alternatives to chlorine-containing compounds and processes. The timetable for these discussions and the actions resulting from them should be reflective of sound science, the current importance of chlorine to society and the lack of alternatives of known safety and effectiveness. It would seem reasonable that known and suspected

considered to be particularly hazardous (e.g., 2,3,7,8-TCDD) when they are present in concentrations above scientifically sound regulatory standards, it should be considered inadequate for protection of public and environmental health and replaced with a more appropriate protocol.

♦ Previously installed industrial processes for which there is inadequate information regarding the identity and/or toxicity of the by-products released to the environment should be subjected to an adequate toxicity testing paradigm. This should be done to provide data indicating the potential of released unknown by-products to produce harm to the environment and public health, and sufficient information to allow a risk/benefit evaluation to be made.

♦ The replacement of chlorine and potentially toxic chlorinated compounds in industrial processes with equally beneficial alternative chemical compounds and processes will require toxicity testing for a new set of products and by-products. Studies involving the use of intact animals, cells and isolated tissues derived from animals will be required. The efficacy of the tests used to evaluate the safety of alternative products and the associated by-products should be equivalent to tests required for chlorine-containing products and by-products.

♦ The current body of chlorine and chlorinated compound-related regulations operable in Michigan may be considered reasonably adequate to protect human health, the environment and the Great Lakes but should be (a) periodically reviewed and upgraded in terms of requiring more appropriate monitoring and evaluation requirements consistent with new environmental and human health data regarding chlorinated compounds and their potential substitutes, (b) ensured of sufficient human and financial resources to allow for aggressive and effective enforcement and (c) supplemented with a monitoring program capable of establishing and tracking changing trends in contaminants impacting both the abiotic and biotic environments.

sheer numbers of these compounds and related studies, and the fact that a majority of chlorinated compounds will not have been studied epidemiologically. Rather, the attempt here was to provide a brief survey of selected studies of certain chlorinated compounds as are found in the Michigan environment. Studies of each of these compounds include those of positive and negative results. Applying a summary statement to the overall toxicity of chlorinated compounds as a group is difficult, if possible at all. However, toxicity of selected members of this group is evident, as identified with several examples above, and the prevalence of chlorinated compounds in Michigan waters warrants continued diligence in studying their health effects.

Chlorine Substitutes

It is estimated that 15,000 of the 70,000 chemical compounds in commerce today are chlorinated (Ehrenfeld et al., 1993). If the use of chlorine and chlorinated compounds is sunset, some form of non-chlorine based substitute would take their place. A critical question is whether these non-chlorine substitutes would be safer and what economic and social sacrifices would be required to make the switch. A simple answer to these questions is not possible due to the numerous uses of chlorine-based products. As a consequence, it is not the intent of this discussion to provide an exhaustive compilation of what the potential non-chlorinated substitutes would or could be, or a quality, cost or safety comparison to the target chlorine-based product. A brief discussion of some of the largest and more well-known uses of chlorine-based products and their substitutes is presented below.

Polyvinyl Chloride (PVC). The largest use of chlorine (about 26%) is in the production of vinyl chloride monomer which is a precursor of PVC (Ehrenfeld et al., 1993; Charles River Associates, 1993; Kirschner, 1993). PVC accounts for about 15% of all plastic sales in the U.S. (Ehrenfeld et al., 1993). There are literally thousands of uses of PVC, including food packaging, flooring, siding, bottles and pipes. PVC is incorporated into automobiles, furniture, buildings, sports equipment, medical supplies, footwear and many other products.

PVC has replaced metals, glass, rubber, wood, paper, cement, ceramics and other plastics either because it was less expensive or it offered better performance characteristics. Thus, loss of PVC would mean higher product costs and/or some sacrifice in performance, as well as a different set of potential environmental hazards. The extent of the added costs, performance loss, or environmental problems depends on the substitutes available, and these substitutes vary widely across the different uses of PVC.

To illustrate, building and construction accounts for about 60% of all PVC use (Ehrenfeld et al., 1993; Johnson, 1991). Pipes, fittings, and conduits account for one third of all building and construction uses of PVC (the second largest construction use, 24%, is resin-bonded woods). PVC is used in pipes, fittings and conduits because it does not corrode or conduct electricity as metals do, and it is more durable and energy efficient. The likely non-chlorine substitute for PVC pipe would depend on the use. For example,

the most likely substitute for PVC in small diameter pipes is polyethylene (Ehrenfeld et al., 1993; Charles River Associates, 1993). However, ductile iron may be the most likely substitute for sewer and drain pipes (Charles River Associates, 1993).

A similar extrusion technology is used to produce pipes from polyethylene compared to PVC. However, polyethylene is more costly to use and has some limitations in comparability of performance. There may also be environmental problems associated with polyethylene, but their extent is unknown (Ehrenfeld et al., 1993). In contrast, increased ductile iron use will require substantial capital investment as well as increased costs per foot installed. Producing ductile iron also results in adverse environmental impacts (Charles River Associates, 1993).

The second largest use of PVC is in packaging (about 8%), particularly bottles (Ehrenfeld et al., 1993). PVC use in packaging is being phased out in some European countries (Johnson, 1991). The primary substitute being used in bottles is polyethylene terephthalate (PET). Coca-Cola and Pepsi-Cola Companies have announced that they plan to use PET bottles, and that PET is more easily and fully recyclable than PVC. PET is more costly to use in making bottles than PVC. However, PET has some performance advantages over PVC, particularly in bottling of carbonated beverages (Ehrenfeld et al., 1993).

Pulp and Paper. The second largest use of chlorine (about 14%) is pulp and paper production (Charles River Associates, 1993). Chlorine bleaching is the primary means of removing residual lignin in wood pulp. In 1992, there were approximately 600 paper mills in the U.S., 104 of which produced bleached kraft pulp. Twelve bleached kraft pulp mills are located within the Great Lakes basin, three of which are in Michigan (Lockwood-Post Directory, 1992). All of the mills use chlorine. Michigan also has approximately 242 pulp and paper and allied manufacturing facilities (USDC, 1993).

It is possible to produce high quality paper from virgin pulp and recycled fibers without using chlorine. The primary non-chlorine substitutes for bleaching pulp are oxygen delignification, ozone bleaching and peroxide bleaching (Ehrenfeld et al., 1993; Patrick, 1993; Colodette et al., 1993). Because of the increased demand for chlorine-free paper in Europe, some pulp mills serving those markets have begun to use chlorine-free processes. There is one chlorine-free paper mill located in the U.S. (in Samoa, California) (Kriz, 1994). Although it is technically feasible to eliminate chlorine from paper production while maintaining adequate product quality, the relative safety of chlorine-free processes remains to be documented.

A ban on chlorine would also affect the use of caustic soda, a co-product of chlorine production in paper mills. As production of caustic soda from alternative methods is undertaken (i.e., using soda ash), increased caustic soda costs will encourage the use of alternative alkali sources in pulp bleaching (Naddeo et al., 1992).

The primary argument against requiring totally chlorine-free processes is that recent environmental improvement investments by the paper industry have significantly reduced

Conclusions

1. The known toxicity of certain chlorinated compounds, particularly those exhibiting persistence, and the possibility that *unknown* products of similar toxic potential are now reaching the environment, or may do so in the future, makes it necessary to evaluate current and future uses of chlorine and chlorinated compounds. Discussions, similar to those called for by the IJC, should take place among industry, government and public interest groups to examine the risks and benefits of the chlorinated products in use. Included in these discussions should be the consideration of safety and effectiveness of possible alternatives to chlorine-containing compounds and processes. The timetable for these discussions and the actions resulting from them should be reflective of sound science, the current importance of chlorine to society and the lack of alternatives of known safety and effectiveness. It would seem reasonable that known and suspected harmful chlorinated compounds or processes could be eliminated over a period of 30 years or less using a priority system addressing health, economic and other societal factors.

2. The addition of chlorine atoms to an organic molecule usually increases its solubility in lipid and often increases the length of time it is present in the environment. The combination of lipid solubility and environmental persistence can result in accumulation of organic compounds in the food chain. In general, a toxic compound which is bioaccumulating in the environment, particularly in the food chain, represents a greater threat to environmental and public health when compared to the threat from an equally toxic compound that does not bioaccumulate.

3. The grouping of chemical substances for regulatory purposes on the basis of physical, chemical and biological characteristics is scientifically defensible whereas consideration of a single property (e.g., contains chlorine) alone is likely to be inadequate for the intended purpose. Thus, persistent toxic chlorinated and non-chlorinated compounds released to the environment can be treated as a group for the purpose of regulatory control. Toxic compounds currently known to be persistent and bioaccumulative in the environment should be vigorously controlled. Procedures to adequately detect these and the many unknown compounds either individually or as mixtures should be implemented.

4. Scientific evidence indicates that all chlorine-containing organic compounds do not have similar potential to produce deleterious effects in humans and in the environment.

5. There is *insufficient* scientific evidence to indicate that the mere presence of non-persistent chlorinated compounds in the environment is producing an environmental or public health threat. Likewise, *insufficient* evidence does not prove lack of potential for harm.

6. Some non-persistent chlorinated compounds including certain volatile organic solvents can produce toxic effects at high exposures that may occur with accidents or in occupational settings. The ability of these types of chemical substances to produce long lasting health effects such as cancer, neurological damage or reproductive deficits as a

result of lower environmental exposures is generally not convincing at this time. Sunsetting of this group of chemical compounds should not occur precipitously.

7. New chlorinated and non-chlorinated products and by-products of industrial processes should be evaluated for their toxicity, persistence and bioconcentration potential prior to being released into commerce and the environment. The toxicity testing applied to products, emissions and effluents from new industrial processes should be sufficiently sensitive to detect adverse effects that might occur in wildlife, domestic animals and humans at concentrations known or reasonably estimated to occur in the environment. The testing paradigm applied should be capable of detecting several types of non-lethal toxic effects including those leading to neurotoxicity, hormone modulation resulting in reproductive and developmental toxicities and immunotoxicity. If the testing paradigm now being used cannot detect the toxic effects of chemical compounds currently considered to be particularly hazardous (e.g., 2,3,7,8-TCDD) when they are present in concentrations above scientifically-sound regulatory standards, it should be considered inadequate for protection of public and environmental health and replaced with a more appropriate protocol.

8. Previously installed industrial processes for which there is inadequate information regarding the identity and/or toxicity of the by-products released to the environment should be subjected to an adequate toxicity testing paradigm. This should be done to provide data indicating the potential of released unknown by-products to produce harm to the environment and public health, and sufficient information to allow a risk/benefit evaluation to be made.

9. The replacement of chlorine and potentially toxic chlorinated compounds in industrial processes with equally beneficial alternative chemical compounds and processes will require toxicity testing for a new set of products and by-products. Studies involving the use of intact animals, cells and isolated tissues derived from animals will be required. The efficacy of the tests used to evaluate the safety of alternative products and the associated by-products should be equivalent to tests required for chlorine-containing products and by-products.