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CHAPTER 13

"THE MICHIGAN EPISODE CHARACTERIZES FEAR WITHOUT FACT AND THE CHALLENGES THAT STATES HAVE IN ESTABLISHING TRUST AND CREDIBILITY WITH ITS CITIZENS."

CASE STUDY: THE MICHIGAN DIOXIN EPISODE

ROBERT W. LEADER AND MICHAEL A. KAMRIN

The public has become increasingly concerned during the past decade about exposure to environmental contaminants. People are uneasy about toxic waste dumps, drinking water pollution, acid rain and a variety of related problems including radioactive waste. Their level of anxiety is due to a number of factors, one of which is the inherent uncertainty in determining the environmental or health effects of any particular chemical. Citizens find it difficult to accept this uncertainty and are reluctant to listen to scientists who say "I don't know" or who heavily qualify their statements. People feel that something is being hidden and that they are not being told the whole story. These suspicions about health effects of toxic chemicals in our environment are magnified when cancer is mentioned as a possibility. The informed public is aware of the ambivalence of scientists in ascertaining and measuring the carcinogenic potential of most chemicals. Unfortunately, suspicions are often reinforced in a number of ways. One contributor is reporting in the press, which tends to reinforce those in the scientific community who make blanket unqualified statements rather than those who talk in terms of probabilities and uncertainties. Major articles in such widely read publications as National Geographic fan the public anxiety. Another factor is the inconsistent treatment of the same chemicals by different governmental units. A third is the seemingly great influence

of large corporations in those matters. Corporations are regarded by many citizens as devious and unobjective in the interpretation of experimental data. Workers at Dow Chemical Company, for instance, have performed the definitive experiments in determining the toxicity of dioxins. Their scientists have led the world in analytical technology on these substances. Yet, because they were the producers and marketers of Agent Orange, their statements are viewed with great skepticism. Members of industry and the government community have become the principal targets of public mistrust, but university scientists are also viewed cautiously by the public. This situation was epitomized by a 1973 incident in Michigan during which cattle were accidentally fed a fire retardant mixture containing polybrominated biphenyls (PBBs). Government agencies were accused of deceiving the public, and official pronouncements were treated with complete distrust. The meat supply of all Michigan was suspect. The state Department of Agriculture was accused of deceiving the public. The governor was attacked for inaction. Newspapers daily published headlines and articles which greatly exaggerated the situation. The university was criticized for inaction and, in general, bumbling the situation. The long-term impact of this incident on the public is clear from the depth of skepticism which remains after more than a decade.

The universities in Michigan, and Michigan State University (MSU) in particular, also lost credibility during this time. As the land grant university in Michigan, MSU had the mission of responding to such incidents and providing the expertise needed to protect the public. The university failed in almost all aspects of this responsibility. MSU scientists could not identify the source of the problem, could not speak with one voice and did not clearly represent an independent, objective position. This was partly due to a lack of appropriate

analytic methods and expertise but, more importantly, to the absence of mechanisms for coordinating the efforts of scientists in the diverse disciplines needed to attack the complex problem posed by exposure of cattle to PBBs.

The Michigan legislature eventually took action to ensure that such an incident could not occur again. A unit, the Center for Environmental Toxicology, was established and funded at MSU to serve as the coordinator for the response of the university to environmental contamination problems. The Center was also charged with the responsibility of elevating and maintaining laboratory capabilities at state-of-the-art levels so that MSU could perform the most advanced research on any chemical that might be found in the environment. The CET was officially established in 1978 but did not reach full operation until 1980, when a permanent Director was appointed.

ISSUES

In the late 1970's, the focus turned from PBBs to PCBs (polychlorinated biphenyls) and in the early 1980's to dioxins and, in particular, one dioxin congener known as TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin). The toxic potential of dioxin had been well established but was underscored as the result of an incident in Missouri involving contamination of soil used in a horse arena. As in the PBB incident, there was extended delay in identifying the chemical responsible. However, in contrast to the PBB situation, the food chain was not affected, and there was not the same urgency to determine the full extent of the contamination. The widespread distribution of dioxins in Missouri did not become clear until the early 1980's, and the new findings led to great public fear and the federal buyout of Times Beach, Missouri, in 1983.

At the same time there was continuing controversy about exposure of Vietnam veterans to dioxins as a result of herbicide applications during the war. Although it was easy to determine that some exposure had occurred, it was not clear what, if any, health problems had resulted from this exposure. A large class-action lawsuit had been filed by the veterans, and emotions were running high.

At about this same time, it was reported that fish in ten Michigan rivers and streams contained detectable levels of dioxins in their tissues. One of these rivers, the Tittabawassee, was also known to be contaminated with other chemicals. This new revelation caused great alarm and led to renewed public distrust of industry and the governmental community. Dow Chemical was the particular target since the Tittabawassee flows past its complex in Midland. Not only was there great concern about possible health effects but also about the economic impact on Michigan's tourist industry.

Thus, in the spring of 1983 there was near panic about dioxins at both national and state levels. There were many unanswered questions, such as: How toxic is it to humans? What are the main sources of dioxins in the environment? How are dioxins distributed once they enter the environment? How long do they last in the environment or in human tissues? and What is the most appropriate public policy toward dioxins? It was not surprising that the public was exposed to conflicting opinions on all of these questions and was unable to decide whom to believe. There was great political pressure for something to be done, but, with all of the uncertainties, it was not clear exactly what needed doing.

SOLUTION

In an attempt to address the issues squarely, Michigan State University decided to sponsor a conference which would bring together experts on all aspects of dioxins ranging from molecular mechanisms of action to public policy. At about the same time, other parties in Michigan were also thinking along the same lines and, fortunately, each was made aware of the other's efforts. In the interests of achieving the best conference possible, MSU took the lead and arranged a meeting with these other organizations. As a result, a unique alliance was formed. MSU was represented by the Center for Environmental Toxicology, the private sector by Limno-Tech, Inc., and the Cranbrook Institute of Science represented non-profit organizations. An organizing committee was established consisting of high level representatives of each of these units. It was soon evident that by working together the committee would be able to attract an international set of conference participants representing the best expertise in each area of dioxin research.

The conference that resulted was entitled Dioxins in the Environment and was held December 6-9, 1983, at Michigan State University. It was made up of two days of plenary sessions and two days of consensus workshops. During the plenary sessions, scientists presented overviews of the state of knowledge in their respective specialties in a way that could be understood by all attendees, not only those in their own disciplines. These presentations provided a common background for the workshops that followed. The workshops covered four major areas: public policy on dioxins; human health and toxicity; source, distribution, and fate; and sampling and analytical techniques. Each workshop consisted of the invited experts supplemented by representatives of industry and government and was charged with examining and summarizing present knowledge and recommending future courses of action in the assigned area.

The meeting was funded partially by the United States Department of Agriculture as part of their Dioxin in the Great Lakes Food Chain grant to MSU, and additional funds were supplied by the Center for Environmental Toxicology. Registration costs were kept low in order to encourage participation from a wide spectrum of individuals from both the public and private sectors. This approach was successful as there were about 250 attendees representing many different organizations and viewpoints.

In order to maximize the usefulness of this conference as a public education tool, media coverage was carefully coordinated to allow media representatives access to the invited experts. News conferences were held twice each day during the plenary sessions, and a wrap-up conference was held at the end of the consensus workshops. At this event, chairs of the workshops read summary reports and answered questions about the deliberations of their respective groups. In addition, the proceedings of this conference, including the workshop reports, were edited and published in book form. This publication, entitled Dioxins in the Environment was published by Hemisphere Publishing Corporation in 1985. edited by Kamrin and Rogers and

CONCLUSIONS

The response from the participants and those who viewed the conference from the outside was overwhelmingly positive. The general feeling was that the consensus reached represented a balanced view of what was and was not known about dioxins at that time and what future priorities should be set. In addition, this conference seemed to have some impact on later state and federal public policy actions which were restrained and reflective of the state of uncertainty that existed.

However, it is not possible for the scientific community to relax in its efforts in public education. There will

undoubtedly be new chemical problems in the future, some even concerning dioxins, and fears that are raised will need to be tempered with knowledge. As this conference has shown, the university, among all possible sources of information, is the most credible and best equipped and, thus, has the greatest responsibility for keeping the public informed. The land grant institutions, in particular, must occupy a leadership position in assembling, analyzing, and presenting to the public the facts concerning possible exposure to and resultant risk from environmental chemicals.

RESULTS OF WORKSHOPS

WORKSHOP ON PUBLIC POLICY:

1. In light of our review of the currently available data and the conclusions of the Human Health Effects and Fate and Transport groups, 2,3,7,8-TCDD is not a chemical rating an exceptionally high public policy priority which diverts resources and public attention from other more widespread and dangerous compounds. However, in those "hot spots," places where major sources exist or major concentrations are found in the environment, appropriate epidemiological and environmental system studies are worthwhile. Thus, sampling and monitoring to locate such "hot spots" should continue. Toxicological mechanism research is also important as it can lead to a fuller understanding of how the classes of dioxins and furans interact with biological systems in man and the environment.

2. Studies involving issues of public concern in identified specific populations or geographical areas should seek the participation of representatives of the affected public. The design should be such that all data are quality controlled before dissemination and that only complete data sets are released. Public representatives should be part of the group evaluating the data, and the data should be released to the affected group at the same time they are released

to the research team.

3. Regulatory actions should seek to protect the aggregate population at risk as well as high-risk populations.

4. Information transfer from scientists to the public should clearly state what is known, what is unknown, and what is uncertain. This recommendation stems from our perception that the public is often inadequately informed on knowns and unknowns and accordingly is unable to deal with uncertainty.

5. A public policy addressing chemical contamination should also include a plan to inform and educate not only the public but also key target audiences such as legislators and legislative aides, community leaders, and media representatives.

WORKSHOP ON HUMAN HEALTH AND TOXICITY:

TCDD is the prototype of a number of other compounds which produce a variety of toxic effects sometimes referred to as the "halogenated aromatic hydrocarbon syndrome." It is unique in that it produces its effects at much lower doses than many others in these groups of compounds. Although many of these related compounds have been studied in animal models over a number of years, there are a variety of reported toxic effects which remain unconfirmed. Even those which have been confirmed often show great species specificity. As a result of these uncertainties, it is difficult to extrapolate from animal data to predict human toxicity.

Unfortunately, studies directly on humans (i.e., epidemiological studies) also have a number of inherent pitfalls. These include mixed chemical exposures, poor exposure history and difficulty in defining toxicological end-points. In the

preceding sections, studies of one particular population, that of Seveso, Italy, have been mentioned specifically as this is one of the few populations where ecologic exposure is known. A number of studies are underway on the Seveso population, and it is important that these follow-up studies continue. Another group that is being carefully examined is the cohort of Vietnam war veterans exposed to Agent Orange. The results of these studies will, it is hoped, shed light on possible long-term effects of TCDD in humans.

The last type of study which can provide valuable information is the mechanistic one. Research of this type has just scratched the surface, but progress is bing made. Ultimately, this research will provide us with an understanding of TCDD action at the molecular level.

The conclusions reached by the workshop participants are given below:

Carcinogenicity

1. The standard bioassay shows that TCDD is an animal carcinogen.
2. Insufficient epidemiological evidence exists to indicate that TCDD is a human carcinogen. Further studies are underway to test this hypothesis.

Mutagenicity

1. While a few studies suggest that TCDD is a weak animal mutagen, the preponderance of data indicate that TCDD is not a mutagen.
2. There is no direct evidence of mutagenicity in humans.

Reproductive Effects

1. TCDD administration can lead to reproductive failure in animals.
2. In Seveso, Italy, a site of massive environmental TCDD contamination, a transient increase in the frequency of spontaneous abortions was observed among women living in the most heavily contaminated areas.

Teratogenic Effects

1. TCDD can produce teratogenic effects when administered to pregant female animals. There is no evidence that it can cause birth defects through paternal exposure.
2. Epidemiological studies have not shown a consistent pattern of birth defects in human populations exposed to TCDD.

Other Effects

1. TCDD has been shown to cause a variety of acute effects in laboratory animals, including the wasting syndrome and thymic involution, which have not been observed in human populations.
2. TCDD exposure is fatal to common laboratory animal species at low levels, but there are great differences in susceptibility between species. Guinea pigs are the most susceptible. Based on the absence of human deaths in TCDD-exposed populations, it appears that humans are not as sensitive as guinea pigs.
3. TCDD has been shown to cause chloracne, actinic elastosis and hyperpigmentation in humans. These effects seem to vary in persistence and severity.
4. There have been less consistent reports of stomach ulcer, porphyria, alteration in serum lipoproteins and neurological disorders in TCDD-exposed humans.

Mechanism of Action

1. TCDD is an enyzme inducer in animals and, most likely, humans. However, it appears that its toxicity is unrelated to the phenomenon of induction.
2. TCDD appears to bind to a cytosolic receptor, but this alone is not sufficient to explain its toxicity.
3. A variety of experimental studies suggest that TCDD is a promoter of carcinogenesis.
4. The mechanism of lethality is still unresolved.

WORKSHOP ON SOURCE, DISTRIBUTION AND FATE:

The final task of the workshop participants was to issue a joint statement regarding the issues discussed during the proceedings and examined herein. These are the unanimous opinions of this workshop session regarding six areas of inquiry. These statements were read to the press and public at the conclusion of the workshop.

1. Sources

In locations where dioxins are observed at elevated levels, their presence is attributable to local sources. This is indeed noteworthy; even though the worldwide total amount of dioxins may originate from many sources, high levels in water, soils and fish are invariably associated with a local source. Therefore, if toxic effects are of concern, these locations and sources would be of special concern. Furthermore, we concluded that the major source of dioxins in terms of elevated levels are typically manufacturers of chemicals which are contaminated with dioxins. This would include the manufacturers' disposal sites. On the other hand, proper application of low concentrations of herbicides that are contaminated with dioxins does not pose a significant contamination event.

2. Distribution of Dioxins

Dioxins and similar chemicals such as furans have approached or are approaching ubiquitous distribution. These chemicals can be distributed to remote areas by atmospheric transport. The introduction of dioxins to the atmosphere occurs due to incineration of wastes and wood, as well as transfer from contaminated soils to the atmosphere. In addition, it was noted that dioxins from incineration are typically composed primarily of less toxic forms of dioxin.

3. Fate of Dioxins

The workshop participants demonstrated that scientists do know the factors which influence the fate of dioxins and furans in our environment and food sources. The problem, however, is that we cannot now quantify the relative importance of these factors. In particular, the field and laboratory data are not available to measure these factors accurately. Fulfillment of these needs, therefore, would require well focused field monitoring programs and laboratory studies.

4. Risk Assessment

In reviewing the process of evaluating how dioxins or other chemicals from a source might impact a human population, we found that many of the requirements of assessment are indeed recognized and that related programs are underway. However, there are specific links in our chain of clearly defining human risk which are missing or inadequate. For instance, in the soils of contaminated areas such as Times Beach, Missouri, and Midland, Michigan, we do not know the exposure levels or the bioavailability of dioxins once exposure occurs.

5. Remedial Alternative

While there have been a number of mitigative actions proposed for sites contaminated with dioxins, including incineration of soil, disposal of soil and containment of soil, the working group recommended that on-site methods of dioxin destruction or decontamination should be examined thoroughly. The session further noted that the contaminated sites at Times Beach, Missouri, would be an ideal site for the testing and refinement of on-site methods of dioxin decontamination. A method of on-site dioxin decontamination meriting further investigation included sunlight assisted destruction.

6. Conclusion

Our understanding of the environmental problems posed by dioxin compounds in the environment is based on a basic understanding of environmental processes and previous experience with related compounds such as PCBs. To respond rationally and in a timely way to problems like dioxin contamination requires a long-term commitment to a strong environmental infrastructure. Only with a scientific understanding of production, sources, fate, and effects of toxic substances will we be able to prevent future environmental crises. In the meantime, we should continue to locate sources of toxic contamination, monitor their impacts, and then eliminate, decontaminate, remove, or seal sites depending on site specific evaluations.

WORKSHOP ON SAMPLING AND ANALYTICAL TECHNIQUES:

The present analytical methodology allows definitive analysis for all dioxins and dibenzofurans for which reference standards are available. These analyses can be carried out at a high level of confidence at the part per trillion level for most matrices and part per quadrillion level for waters. Several analytical schemes have been used to achieve these detection limits. However, it is recognized that in order to analyze and validate such samples, extraordinarily vigorous quality assurance procedures (multi-laboratory) must be employed.

We feel confident that all the dioxin and furan congeners can be determined as soon as reference materials become available. It is of primary importance that the analytical chemist be involved in the initial planning of studies and that a concise set of goals be included as part of the protocol for each study. There is a need for continuing collaborative studies for all laboratories involved in dioxin and furan analyses.

For instance, it is possible to determine a single isomer such as 2,3,7,8-TCDD with a minimum of expenditure of time and money, but if the goal is to determine sources, then all isomers must be determined at a greatly increased expenditure of cost and time.

~~Kamrin, M.A. & Rodgers, P.W., Dioxins in the Environment, Hemisphere Publishing Company, Washington D.C.~~

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1. Kamrin, M.A., Rodgers, P.W. (1985), Dioxins in The Environment. Hemisphere Publishing Corporation, Washington DC, 328p.