Public Health Then and Now

Environmental Politics and Science: The Case of PBB Contamination in Michigan

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Abstract: This article examines how politics and science interacted against a background of uncertainty to shape policy in the case of environmental contamination by polybrominated biphenyls (PBB) in Michigan. In 1973, between 500 and 1,000 pounds of the flame retardant PBB were accidentally shipped and used instead of the dairy feed additive magnesium oxide, resulting in the widespread contamination of animal feeds, animals, and human food products. The contamination was initially perceived as the private trouble of a single farmer. The problem next became a public issue as public and private institutions grappled with questions of illness, safety, and disposal. To gain influence over those institutions, dissatisfied individuals and groups then turned the PBB contamination into a political controversy. The final section of the present article analyzes how science and politics interacted in: the ways bureaucratic organizations defined the three problems of contamination; the role political controversy played in redefining problems and influencing policy; and the political roles of scientists in controversies over environmental contamination. (*Am J Public Health* 1983; 73:302–313.)

Introduction

Contamination of the environment by toxic chemicals raises difficult problems of illness, safety levels, and disposal. These problems often contain large areas of scientific uncertainty and affect conflicting interests in society. When that happens, toxic problems are resolved not simply as technical matters but become complex public issues and political controversies.[1] The combination of scientific uncertainty and conflicting interests makes decisions about policy depend on value judgments and political bargaining, as well as scientific information. Another reason for political controversy is that dissatisfied groups seek to expand the scope of a public issue into the political realm to get what they want.[2]

The sources of uncertainty in environmental contamination are many. Environmental exposures are usually low-level and long-term, and can interact with other factors. The chemicals often accumulate and persist in the environment and in human tissue, creating a continued presence in the food chain and a continued internal toxic burden for people. The increased risk of cancer and of reproductive hazards due to environmental pollutants exist against a background of those same risks associated with other causes, making epidemiological studies extraordinarily difficult and indecisive.

Epidemiology has other uncertainties as well. Studies may be inadequate in design or measurement. The population under study may be too small to detect an infrequent but meaningful effect that is occurring. The population may be studied at an inappropriate interval after exposure, so that the effects have already occurred and disappeared or have not yet occurred. The study may involve a subpopulation not susceptible to the exposure. The institutional context of epidemiology also produces uncertainties. Those problems can result from lack of manpower, lack of resources, or lack of understanding of epidemiology's purposes and uses.[3]

These uncertainties of scientific information pose a dilemma for regulation. Steven Jellinek, a former official in

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TABLE 1—Agricultural Cases of Chemical Contamination Reported in 1976

State	Year	Animal	Estimated Value	Contaminant
Arkansas	1969	poultry	$4,000,000	Heptachlor
Missouri	1969	cattle	50,000	Dieldrin
Oregon	1969	cattle	250,000	Dieldrin
New York	1970	poultry	500,000	Dieldrin
New Mexico	1970	swine	63,000	Mercury
North Carolina	1971	swine	10,000	Dieldrin
New York	1971	poultry	1,000,000	PCB
Southeast US	1971	poultry	2,500,000	PCB
California	1971	poultry	50,000	PCB
Georgia	1971	poultry	2,500	Dieldrin
Maine	1972	poultry	3,000,000	PCB
Minnesota	1972	poultry	336,000	PCB
Maine	1972	poultry	150,000	Dieldrin
Missouri	1972	poultry	78,000	Dieldrin
California	1972	poultry	90,000	Dieldrin
North Carolina	1973	poultry	2,000,000	Chlordane
North Carolina	1973	poultry	88,000	Dieldrin
Louisiana	1973	poultry	20,000	Dieldrin
California	1973	lambs	25,000	HCB
Missouri	1973	poultry	567,000	PCB
Louisiana	1973	cattle	400,000	HCB
Mississippi	1974	poultry	6,900,000	Dieldrin
Michigan	1974	cattle & poultry	75,000,000* (approx.)	PBB

SOURCE: See reference no. 6.
*In 1979, the estimated cost of PBB contamination in Michigan was $215,000,000.

the US Environmental Protection Agency (EPA), wrote that the regulator must make decisions about chemicals "in the midst of pervasive uncertainty." Since the regulator does not have "the luxury of putting off decisions until certainty arrives," there exists an "inevitability of being wrong" sometimes.[4] Yet regulators prefer to present their decisions as if based on certainty. For public legitimacy, they prefer their decisions to appear grounded on scientific fact and to mask the margins of error. Scientific uncertainty thus tends to be overwhelmed by organizational demands to maintain routine procedures and to protect policy spaces. Once an agency becomes committed to a position, the uncertainty tends to fade away and the definition of the problem tends to resist change.

Some toxic victims and their allies contest the bureaucratic definitions of illness, safety, and disposal. They use social conflict to expose uncertainties and values of existing policies, and to provide pressures and incentives for changes in policy. In such controversies, scientists are not detached technical specialists but are active political participants. Cases of toxic contamination thus raise problems of politics in science and of science in politics.

In 1973 and 1974, the State of Michigan suffered one of the worst chemical disasters in United States history. By the end of 1975, as a result of contamination by polybrominated biphenyls (PBB), about 28,900 cattle, 5,920 pigs, and 1.5 million chickens had been destroyed; buried around the state were 865 tons of contaminated animal feed, 17,940 lb of cheese, 2,630 lb of butter, 34,000 lb of dry milk products, and nearly 5 million eggs.[5] No one knows the total cost of cleaning up the statewide contamination, but estimates reached the hundreds of millions of dollars (see Table 1).[6] In addition, even five years after the contamination, about 97 per cent of Michigan's residents showed measurable levels of the chemical and the most highly exposed groups showed little significant decline in PBB levels.[7] The possible long-term health consequences remain a point of concern and uncertainty.

This essay explores the interaction of science and politics in the Michigan case of PBB contamination. It first reviews the discovery and the causes of the contamination. It then examines how and why the problems of illness, safety, and disposal became public issues and political controversies. The final section analyzes how public policies for PBB contamination were affected by bureaucratic processes, political conflict, and involved scientists.

A Private Trouble

For about one year, from the time the contamination occurred in May 1973 until the contaminant was identified in April 1974, the problem was considered a private trouble, the difficulty of a single dairy farmer. That farmer, Rick Halbert in southwest Michigan, first noticed health and production problems in his herd of 400 dairy cows in September 1973. Halbert checked for the usual infectious diseases, but the symptoms did not fit. His veterinarian then examined the cows, but he too could not diagnose the unfamiliar illness.

Both men suspected something wrong with the feed, possibly in a recent order of high-protein feed pellets sup-

plied by Farm Bureau Services, Michigan's largest feed distributor and a subsidiary of the state's most important farmer organization, the Michigan Farm Bureau. Although the company denied any problems, Halbert decided to run an experiment and gave 12 of his own calves a diet of only the pellets. Within six weeks, five of the calves had died.

From the experiment with calves and from observation of the herd, Halbert and his veterinarian noted two phases in the cows' symptoms. The first phase included decreased appetite and milk production, and increased urination and tearing. In the second phase, cows developed hematomas and abscesses, abnormal hoof growth (becoming long and curling upward), matted hair that eventually fell out, and severe reproductive abnormalities.[8]

At Halbert's urging, the State Department of Agriculture repeated the feed tests, but the state used mice not cows. In two trials, all treated mice died. Even then, the president of Farm Bureau Services insisted that the feed was pure and healthy. The company veterinarian, Dr. James McKean, explained to Halbert that the mice died because they had eaten "cattle feed" not "mice food." Halbert considered that nonsense.[9]

In early 1974, however, the feed company began to accept that a problem existed in its high-protein feed pellets. The company hired research institutes to conduct chemical analyses of the feed and to perform a feeding trial on calves. The company, however, did not report the feed problem to public officials, and the company veterinarian misrepresented experimental results and other information to Halbert on several occasions.

Halbert, meanwhile, continued to seek help from state and federal scientists to identify the poison in the feed. Many responded that they could not study the problem of a single farmer. But others agreed to help.

In March 1974, a toxicologist analyzing the feed with gas-liquid chromatography accidentally left the machine on for the unusually long time of eight hours, producing an unexpected series of peaks and indicating the presence of an unidentified chemical. One month later, the feed was analyzed by low-resolution mass spectrometry. Halbert passed the results to a scientist in the US Department of Agriculture, who immediately recognized the compound as one he had worked with: polybrominated biphenyls, a flame retardant produced by Michigan Chemical Corporation. This company, Halbert learned, sold magnesium oxide to Farm Bureau Services, which added the substance to dairy feed, to increase cows' milk and buttermilk production. Apparently, there had been a mix-up.

In April 1974, when first informed of the mix-up, Michigan Chemical denied that its PBB product, Firemaster BP-6, could have been confused for its magnesium oxide (MgO) product, Nutrimaster. Company officials explained that the two products were stored and manufactured in separate buildings, and were totally different in consistency and color: BP-6 was chunky and amber, and MgO was granular and whitish. In addition, the company reportedly packaged the chemicals in color-coded bags, one bright red (BP-6) and the other royal blue (MgO).

On April 30, however, an inspector for the federal Food and Drug Administration (FDA) discovered a half-used bag of PBB in a Michigan feed mill, thereby linking Michigan Chemical with the sick cows. But the bag was Firemaster FF-1, from an experimental batch of PBB in which the chemical was ground into powder and mixed with an anticaking agent (calcium polysilicate). The special processing transformed BP-6 into a substance remarkably similar to magnesium oxide in both consistency and color. Moreover, the discovered bag was *not* color-coded, and its label did *not* list ingredients or manufacturer. The plain brown bag showed only the trade name, Firemaster FF-1, stenciled across the top. Once the bag was opened, even those meager markings became nearly impossible to read.

Several factors at Michigan Chemical thus contributed to causing the mix-up. In spring 1973, Michigan Chemical ran out of color-coded bags and used plain brown 50-pound bags for both PBB and MgO. Neither product was clearly or adequately marked. Also, according to an internal company memorandum, the storage of the experimental FF-1 was "*very* poor," with broken bags in some warehouse areas.[10] Additional confusion occurred because Michigan Chemical used three different commercial names for its MgO product.

Problems also existed at the feed company, Farm Bureau Services, as detailed in sworn court statements of several employees. The men employed to mix the feeds had little job training, and one employee could not read well enough to recognize the word "Nutrimaster." Some employees, however, could read perfectly well and did report to a supervisor the appearance of a new trade name in the warehouse: "Firemaster." The supervisor told them it was just another name for MgO and to keep adding it as required.[11] Estimates of the amount of PBB introduced into the dairy feed, as a result of the mix-up, ranged from 500 to 1,000 pounds, although it could have been more.

Michigan Chemical first manufactured PBB in 1970 as a fire retardant for molded plastic parts, such as the cases of televisions, typewriters, and business machines. Firemaster BP-6 contained mostly hexabromobiphenyl (about 60 per cent), and several additional isomers. Production of Firemaster BP-6 rose rapidly, from 20,000 pounds in 1970 to 2.2 million pounds in 1972, to 4.8 million pounds in 1974. For Michigan Chemical and the company's owner, Northwest Industries, PBB became a successful product.

In the early 1970s, Michigan Chemical recognized some possible health problems with PBB. A private firm tested the acute toxicity of Michigan Chemical's PBB product and, in 1970, concluded that Firemaster BP-6 was non-toxic for ingestion or dermal application, not a skin or eye irritant, and not highly toxic when inhaled.[12] But in late 1971, Michigan Chemical prepared for workers a one-page health and safety statement on BP-6 that recommended against prolonged exposure and noted that the BP-6 probably accumulates in fatty tissue and the liver, "which certainly is undesirable and possibly could be dangerous." The statement warned against allowing BP-6 to contaminate any food or feed.[13]

Other private companies considered the probable chronic toxicity of PBB too risky for production. In the early 1970s, two of America's largest chemical companies, Dow

and DuPont, separately performed animal laboratory tests on similar PBB compounds. Both companies decided not to manufacture a PBB product, because the tests showed detrimental toxic and environmental effects—evidence of liver damage, bioaccumulation, and high probabilities of carcinogenicity and teratogenicity—and because of knowledge about the high toxicity in humans of a related compound, polychlorinated biphenyls (PCB). The companies publicly announced their decisions and their research in 1972.[14,15]

The PBB mix-up in Michigan thus created a major case of contamination with a relatively unknown but probably toxic chemical. For about nine months, while the problem was considered Halbert's private trouble, Michigan farmers and consumers unwittingly ate dairy and other farm products contaminated by PBB.

A Public Issue

With the contaminant identified as PBB, state and federal agencies officially recognized the problem as not just Halbert's personal plight. Once the contaminant and the problem had a name, the problem was transformed from a "private trouble" into a "public issue."[16] Private and public institutions then began taking more effective steps to deal with the contamination.

But public officials were slow to understand the scope of the problem. Both federal and state governments initially underestimated the extent of the contamination. In May 1974, state agriculture officials repeatedly announced that PBB affected only a "very few farms." Officials publicly defined the problem as an agricultural problem affecting a small group of farmers.

Official policy also did not fully recognize the complexity of the contamination problem. In confronting PBB contamination in May 1974, government officials tried to deal with three questions: *illness*—Which people and animals are "sick"?; *safety*—What levels of PBB contamination are "safe"?; and *disposal*—How should contaminated goods be disposed? These three problems became the issue to be addressed, understood, and resolved. But as Michigan Health Director, Dr. Maurice S. Reizen, later recalled: "No one . . . immediately recognized the full extent of the problem, its urgency, or its real and potential impact on the economy, the health and the lives of Michigan people."[17]

In the spring of 1974, few people in Michigan or elsewhere had heard of PBB. According to one state official, Dr. Kenneth Wilcox, the Michigan Department of Public Health started with "absolutely zero knowledge" about the chemical.* Even federal agencies lacked information on PBB. The FDA, for instance, found few scientific studies to help determine what level, if any, might be safe in human food. The main experimental study available compared the capacities of PBB and PCB to increase the activity of the liver's microsomal enzymes, which are involved in metabolizing toxins and drugs. It showed PBB on a molar basis to be five times stronger than PCB.[18]

Nonetheless, on May 10, 1974, about two weeks after identification of the contamination as PBB, the FDA set an "action" level of 1.0 part per million for milk and milk products (on a fat basis). An "action" level is not a "tolerance," which requires formal and public procedures, but is a temporary administrative guideline that can be informally and quickly set by the FDA. It requires no public participation, can be based on incomplete scientific data, and can stand for years before a tolerance level is set. It provides for relatively quick regulatory action, despite scientific uncertainty.

FDA scientists chose the action level for PBB solely on measurement capability, officials explained, since the Food, Drug, and Cosmetic Act requires in cases of "avoidable" contamination that the guideline be set at the lowest detectable level. The scientists also regarded 1.0 ppm in milk and milk products as probably safe, since the PCB "temporary tolerance" in the US then was 2.5 ppm, and the PBB molecule is heavier than the PCB molecule.[19] About one month later, the US Department of Agriculture set the same level for meat.

Using the federal guideline for food safety, the State Department of Agriculture began to quarantine dairy farms in Michigan, attempting to keep additional PBB-tainted products off the market and to contain the contamination. By the end of May 1974, the state had quarantined 30 farms; these farms had all bought feed from Farm Bureau Services.

PBB poisoning in cattle and other animals was initially defined by the level of contamination. State and federal agencies used the FDA action level for human food to indicate the health of animals. In spring 1974, very little scientific literature existed about PBB effects in cattle. But officials reasoned that if humans could safely consume milk and meat contaminated up to 1.0 ppm of PBB, then the animals that produced the milk and meat would be considered healthy. That definition of illness in animals gradually became a focus of controversy, as farmers questioned its accuracy.

As with animal illness, the main controversy over illness in people centered on the definition of PBB poisoning: Who was sick due to PBB contamination? Again, no scientific reports existed about the health effects of PBB contamination for people, but many studies had been published about human poisoning due to a related chemical, PCB. The high toxicity of PCB in humans suggested that PBB might also cause human health problems.

The State Department of Health first performed a screening of 211 farm people. The Department concluded in July 1974 that although PBB could be detected in the farmers' blood, and some people showed medical disorders, the results "have not revealed a medical syndrome, or group of symptoms, which can be related to PBB."[20] The State Health Department next designed a "short-term" epidemiological study of 300 persons, divided into a PBB-exposed group and a non-exposed control group. But the results of that study were not made public until spring 1975, when they became a focus of controversy, as discussed below.

*Interview with Dr. Kenneth Wilcox, Bureau of Disease Control and Laboratory Services, Michigan Department of Public Health, August 22, 1978.

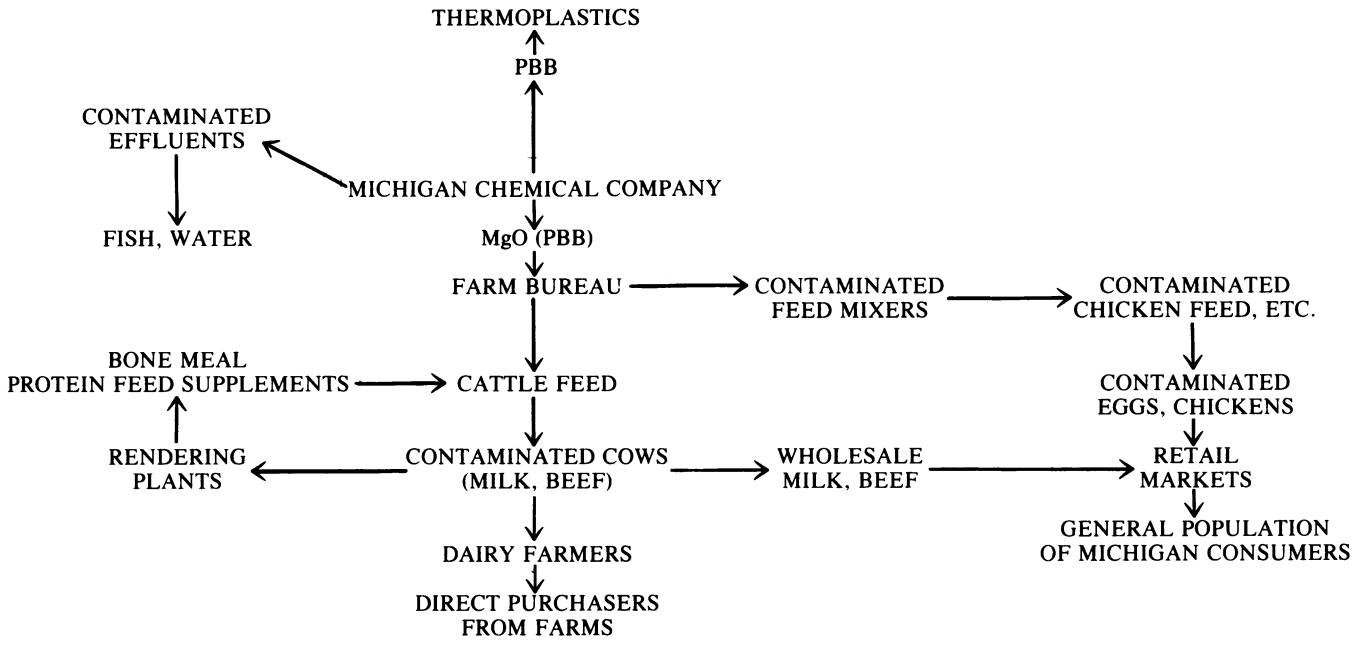

FIGURE 1—The Pathway of Polybrominated Biphenyl (PBB) Environmental Contamination in Michigan

SOURCE: Selikoff IJ, Anderson HA (reference no. 25).

The FDA also conducted a survey of health problems in all quarantined farm families in May and June 1974. That survey similarly found various human health problems, but the federal agency did not analyze or publicize the data. The survey and its results remained unknown to the subjects and to the public until revealed in 1977 by a Congressional investigation.[21]

In the matter of disposal, the state initially had no idea what to do with PBB-contaminated animals. It therefore instituted quarantines until it could decide on an appropriate policy. In early July 1974, nearly two months after the first quarantine, the governor signed a law to open a disposal site for killing and burying contaminated animals. The law allowed the state to condemn animals, to approve disposal facilities, and to use a civil suit to recover costs from the responsible companies. But state officials decided *not* to condemn any animals and *not* to order disposal, because they did not want to open the possibility for farmers to file suit against the state or for the state to be held financially responsible. The state thus quarantined farms and monitored the disposal operation, while the farmers and the companies decided on their own whether to destroy the animals. Farmers, in turn, felt enormous pressure to dispose of their animals. As Halbert put it: "Farmers were simply shut off from their markets and stuck with useless animals—after months of going backwards in double time, most farmers who were faced with this impossible ruinous situation agreed to have their animals destroyed."[22]

Another problem related to disposal arose in July 1974. People living near the disposal site, in the sparsely populated area of Kalkaska County in north-central Michigan, opposed the plan. Two days after the site opened, the county's commissioners filed a lawsuit to stop the disposal. The state had never informed local officials about the disposal plan. The trial delayed the start of disposal for another two months. But even after that time local opposition persisted to the burial of PBB-contaminated animals.

In November 1974, the FDA lowered the PBB action level for food from 1.0 to 0.3 ppm. Publicly, the agency explained that the reduction resulted solely from improved analytical capability, as required by law.

But other factors also influenced the decision. In the summer of 1974, some farmers began to complain about animals contaminated below 1.0 ppm that suffered from symptoms similar to PBB toxicity, with serious economic consequences. Then in the fall, two FDA veterinarians, Drs. Richard H. Teske and D. J. Wagstaff, defined in an unpublished study a chronic syndrome in cows of PBB poisoning that included higher rates of mortality, reproductive problems, and congenital abnormalities.[23] The study confirmed the farmers' observations about health disorders in cattle contaminated below the FDA action level of 1.0 ppm and provided an additional stimulus for change in policy. A third important factor was an experimental study independently initiated by a Michigan scientist, Dr. Thomas Corbett, showing that mice fed high doses of PBB developed gastrointestinal bleeding, enlarged livers, and birth defects—including cleft palate and brain defects.[24] After obtaining his results, Corbett urged state officials in September and October 1974 to lower the PBB action level.

By fall 1974, public officials recognized a broader contamination problem than initially understood. The contamination resulted not only from the initial mix-up of PBB and MgO, which affected herds like Halbert's at a high level, but also from widespread secondary contamination (see Figure 1).[25] Machinery that mixed feed passed PBB to other animal

feeds and feed additives that did not directly include MgO. And animals unsuited for human consumption were slaughtered, processed, and added to feeds. These two feedback cycles helped produce a low level of chronic contamination throughout Michigan's farm animals—not just cattle—and throughout Michigan's food chain.

The new action level, by defining a much larger group of cattle as unfit for production or consumption, expanded the problem of disposal. By November 1974, the state had quarantined about 10,000 cattle, and about 9,000 had been killed and buried at Kalkaska. Under the new action level, the number of cattle for disposal rose rapidly. The State Department of Natural Resources had approved the Kalkaska site for the burial of 13,000 animals, but burial continued far beyond that number. The Department agreed to continue disposal there because no other site was available and because it seemed safer than burying on individual farms. In 1976, when the Department of Natural Resources closed the area, the Kalkaska site held about 30,000 animals.[26] While local residents argued that the burial site was not safe with that many decaying PBB carcasses, officials from the Department of Natural Resources contended the site posed no threat to public health.

The new action level also affected policies on compensation for damages. Farm Bureau Services and Michigan Chemical had begun in summer 1974 to settle out of court with farmers whose herds were quarantined by the 1.0 ppm level. The new action level greatly expanded the number of claimants against the companies, and raised the stakes for everyone involved.

A Political Controversy

Even with the new federal level in November 1974, some farmers complained about cows measuring below 0.3 ppm in milk and meat—"low-level" animals—that were sick and unproductive. The demand to lower the action level arose again from farmers but also from politicians and the press as the problem became a political controversy. These groups redefined the issues from an agricultural problem involving some farmers to a public health problem involving all Michigan consumers. And that new definition compelled changes in policy.

In early 1975, the Michigan press published prominent reports of human illness allegedly due to PBB. By March, state and federal officials had become concerned about public "panic" in Michigan over PBB.

Partly as a response, the FDA sent six veterinarians to Michigan in March to survey the health status of state dairy herds, especially to study health problems of low-level cattle (under 0.3 ppm). Their report concluded that no significant differences in health problems could be found between 16 "PBB-exposed" cattle herds and 15 "non-exposed" herds.[27] But that survey had various defects. Most glaring was that only two control herds were negative for PBB. Data on other herds were alleged to be "not available"—even one year after the survey's completion. Feed used on both exposed and control farms was contaminated with PBB. And one farm in the control group was later quarantined.

One FDA scientist recommended a more competent epidemiological survey of cattle, with follow-up studies, to separate two groups: cattle with low levels of PBB that were survivors of earlier high-level feed contamination and showed clinical symptoms; and cattle with low levels of PBB that were later exposed to low-level feed contamination only and showed no clinical symptoms.[28] The head of the veterinary team rejected the suggestion and the epidemiological approach.

Also in March 1975, the Michigan legislature passed a resolution urging the Agriculture Commission to hold a hearing on the removal of all food products showing a detectable level of PBB. To review the proposed reduction, the State Department of Agriculture held a public hearing in late May. Scientists from state and federal agencies testified that a lower level was not necessary, while one Michigan doctor (Dr. Walter Meester) and several farmers called for reducing the levels to protect public health. Not surprisingly, the Michigan Agriculture Commission rejected the proposed reduction and upheld the FDA action level.

At that hearing, the Michigan Department of Public Health presented the results of its short-term health survey. The study found no significant difference in health problems between the supposedly exposed and control groups, and therefore concluded that no disorders could be associated with PBB.[29] But a respected clinical toxicologist in Michigan, Dr. Walter Meester, criticized the state's survey, particularly because 70 per cent of the subjects in the control group had detectable PBB blood levels. Meester concluded that the state's study was "poorly planned, does not conform to the standards of adequate scientific, medical and epidemiological evaluation, was incomplete, possibly biased, and does not support the conclusions reached and publicized in the lay press."[30]

In fall 1975, farmers increased their public complaints and protests about the state's handling of the PBB contamination and about persistent animal health problems on farms contaminated at low levels. In November, farmer Al Green dramatically protested the state's refusal to help farmers with cattle contaminated by low levels of PBB. In an act that gained national media attention, he and other farmers with low-level cattle shot and buried the farmer's herd of 112 cows and calves.

Farmers moved their complaints to the political arena in early 1976. In March 1976, a committee from the state legislature held several public hearings in farm districts to collect first-hand accounts of problems associated with PBB contamination. At these meetings gathered farmers with cattle contaminated at low levels. As the farmers spoke publicly, they discovered common troubles. The farmers especially criticized bureaucrats who blamed herd health problems not on low levels of PBB but on "poor management"—that is, on the farmers themselves. Two weeks after the last hearing, farmers organized a march on the state capital, and dumped the carcasses of PBB-contaminated cows on the steps of the state capitol building to confront the politicians with the PBB problem.

Just before the farmers marched on Lansing in March 1976, Michigan's governor appointed an advisory panel of

scientists to review all technical data on PBB. In late May, that blue-ribbon panel delivered its report and surprised the governor and his bureaucracy by unanimously recommending a reduction in the PBB guideline to the minimum detectable limits—because of the compound's similarity to PCB, its accumulation in tissue, and the high probability that it causes cancer and birth defects.[31] Subsequent research found neoplastic nodules in livers of four of five rats 10 months after a single dose of 1 gm/kg body weight, supporting early suspicions that PBB is carcinogenic.[32]

The State Agriculture Department, in June 1976, held another public hearing to review the FDA action level and the blue-ribbon report. At the hearing, FDA official Dr. Albert C. Kolbye Jr. testified that available toxicological data suggested that 0.3 ppm was probably safe, and that the agency was no longer required by the Food, Drug, and Cosmetic Act to lower the action level, because the agency considered the contamination had changed from "avoidable" to "unavoidable." The Michigan Agriculture Commission followed the FDA and refused again to alter the PBB action level.

One study that the expert panel and the public hearing did not review was an FDA experimental feeding of PBB to beagle dogs that showed immunological effects. Although the study was begun in November 1975, and the animals sacrificed in January 1976, analysis of the data did not occur until October 1977, after a Congressional committee publicly questioned FDA officials about the experiment and its findings.[33]

When Michigan's executive branch refused to lower the PBB level, the state legislature began to debate a bill to lower the federal level within Michigan by state law. About one year later, in August 1977, the state legislature passed a law that reduced the state's PBB action level from 300 parts per billion (ppb) to 20 ppb in cattle fat, and required a test of each cow sent to slaughter. The Michigan Department of Agriculture and Michigan Farm Bureau had desperately opposed the bill, but public concern and political action about the public health consequences of PBB contamination forced approval of the law—four years after the contamination of Michigan began.

A key group active in pushing for a new PBB policy was farmers with herds contaminated at low levels. In August 1976, these farmers formed the PBB Action Committee, to bring their complaints about state policy to the politicians, to the press, and to the public. The group, stressing that low levels of PBB could damage animal and human health, helped redefine the PBB problem as a public health hazard to Michigan consumers. Many group members also had filed damage suits against the companies responsible for the PBB contamination.

The discovery of widespread PBB contamination of Michigan residents also helped redefine the PBB problem as a public health hazard. In August 1976, the Department of Public Health found that 22 of 26 samples of human breast milk from the general population in Michigan showed the presence of PBB, while none of 10 samples from women outside Michigan contained even a trace of the chemical. In announcing this news to the public, Health Director Reizen expressed uncertainty about the health consequences of the finding but nonetheless did not recommend that women discontinue breast feeding.[34] Later, a more scientific study detected PBB in the breast milk of 95 per cent of nursing mothers tested in Michigan's lower peninsula.[35]

Additional evidence about the human health consequences of PBB became an important argument to lower the state's PBB action level. In November 1976, an eminent clinical epidemiologist from New York, Dr. Irving Selikoff, arrived in Michigan with a 35-member medical team to examine farm families exposed to PBB. In early January 1977, Selikoff stated in a preliminary report that real health problems existed among Michigan dairy farmers and that those problems could be related to PBB exposure.[36] Michigan Health Director Reizen responded: "This is the first time that I can recall we have knowledge about what PBB effect is on people."[37]

The formal reports from Selikoff's study supported the early evaluation. A comparison of the Michigan farmers with farmers in Wisconsin found significantly more musculoskeletal problems in the Michigan group, especially joint disorders (pain, swelling, and crepitation) and neurological symptoms (more tiredness, fatigue, headaches, dizziness, and unusually long sleep hours).[38] Two indicators of liver function, SGOT and SGPT, were also significantly higher in Michigan men than in Michigan women and than in the entire Wisconsin group. These increases did not correlate with alcohol consumption, thereby supporting PBB as probable cause.[39] Also, Michigan farmers showed immunological abnormalities (including decreased number of circulating lymphocytes and altered responses to tests of functional integrity of these cells) when compared with Wisconsin farmers and New York City residents.[40]

Selikoff's findings influenced public views and public policy in Michigan, despite a conflicting study by state and federal health officials. The government study found no dose-response relationship. It reported the most symptoms among farmers with low-level PBB cattle contamination but not enough for compensation. The report concluded that bias in selection factors and other non-PBB factors produced the appearance of a higher number of symptoms in the low-level PBB farmers when compared with the control group.[41]

The legal questions of animal health problems were settled through litigation and negotiation. While farmers with animals contaminated above 0.3 ppm were slowly receiving compensation from the insurance companies of Michigan Chemical and Farm Bureau Services, farmers with low-level contaminated animals continued with no payment whatsoever. Many of these low-level-contamination farmers filed civil damage suits against the companies involved. The first case went to trial in February 1977, and became the longest and most expensive litigation in Michigan history. In October 1978, after 16 months in court, 63 witnesses, and 25,000 pages of court transcript, the judge ruled against the farmer and for the companies. Simply stated, the judge decided that the farmer's lawyers had not proved any damage to the health of the dairy cows or any reduction in milk production due to low-level PBB contamination.[42] Other low-level farmers subsequently settled out of court for small fractions of their losses.

The question of human health problems due to PBB

continued to be debated. In October 1977, lawyers for 246 persons filed a civil damage suit against the companies for PBB syndrome, including symptoms of fatigue, loss of balance, impotence, and aching joints and muscles. But this suit never went to trial. In 1979, as part of an out-of-court settlement, the plaintiffs withdrew their court claims of present (but not future) human health damages. In 1980, a representative of the State Department of Health wrote: "Although people have complained of health problems . . . it has not been proven scientifically that PBB is directly responsible." That person recognized, however, that no one has repeated Selikoff's survey of the low-level farmers,[43] suggesting that his findings have not been disproven. Many questions about health problems thus remain unresolved.

The question of disposal was raised again by the state's new action level in October 1977, since the state needed another burial site. Rural residents who lived near the newly selected site at Mio in Oscoda County formed a local chapter of the PBB Action Committee to oppose in court and in demonstrations the state's policy on disposal. Even though the cattle for burial at Mio contained extremely small amounts of PBB (estimated at a total of two ounces in 3,500 animals), opposition persisted. Under court order, some animals were buried at Mio.[44] Then in 1979, local opposition forced the state to ship 1,500 PBB-contaminated carcasses to a burial ground for radioactive wastes in Death Valley, Nevada.[45]

Another problem of disposal arose in the late 1970s, as some farmers discovered low-level PBB contamination of their lands and buildings. The presence of contaminated animals from 1973 to 1976 had created a diffuse and long-lasting pollution of soils and dusts on some farms. Even new animals brought to the farms became contaminated by low levels of PBB. The farmers once again confronted problems of whether the milk from their animals was safe, whether their animals were healthy, how to clean up their farms, and who would pay for damages.

The controversies over illness, safety, and disposal thus combined to make PBB a major political issue in Michigan. The organized group of farmers and the public sense of crisis pushed the state legislature to pass measures to remove the last PBB-contaminated cattle from farms and to provide loans to suffering farmers. Then, in the fall election of 1978 for governor, PBB contamination again became intensely political, when Democratic challenger William B. Fitzgerald made Republican Governor Milliken's alleged mishandling of the PBB disaster into a central issue of the campaign. In October 1978, when the judge in the low-level-contamination herd trial ruled against the farmer, he also suggested that the state government had not mishandled the contamination problem, although that was not an issue in the case. The judicial decision just before the election greatly boosted the incumbent governor's campaign, and two weeks later he was reelected. PBB then faded away as a political controversy.

Science and Politics

For about five years, with some ups and downs, Michigan people lived PBB politics.[44,46] During that period, the politics of PBB remained intimately interwoven with the science of PBB. That mixing of science and politics resulted from the complex nature of the issue, from the uncertain character of the science, and from the high stakes of the interests. These traits affect various technical controversies, not just chemical disasters like PBB contamination in Michigan. Such technical controversies can be better understood by analyzing three patterns in the interaction of science and politics: the power of government agencies to define the problem; the ability of political conflict to produce changes in policy for technical issues; and the role of scientists as political participants in controversies.

The Persistence of Bureaucratic Definitions

The definition of a problem tends to become frozen in the position of a bureaucratic agency, and thereby to resist change. Organizational theorists Cyert and March wrote that organizations seek to avoid uncertainty by following routine procedures and do not predict problems but respond to feedback. Organizations thus tend to "move from one crisis to another" while relying on standard operating procedures to make decisions. The structures and strategies of public and private institutions thus can contribute to inadequate understanding and inappropriate responses to new problems.[47]

In the PBB case, Halbert confronted the powerful inertia of public and private organizations, when state agencies and the feed company insisted that his cattle problem represented a private and not a collective trouble. Halbert struggled against the narrow definition of his problem, a definition that served as a form of blaming-the-victim.[48] Later, farmers with cattle contaminated at low levels struggled against similar efforts to blame the farmers for their contaminated cattle's health problems. As with other social problems, the PBB case reminds us that to influence policy individuals and groups must transform a private trouble into a public issue and often into a political controversy.[49]

In each area of illness, safety, and disposal, government officials publicly presented decisions as correct, even when surrounded by various uncertainties. The Michigan Department of Agriculture, for example, adamantly supported the 0.3 ppm level as safe and persistently defined low-level cattle as healthy. The Department's defense of the 0.3 level arose not only from its assessment of scientific evidence but also from a structural conflict of interest. The Department was supposed to protect both the common consumer and the agricultural industry, but the Department leaned more toward protecting the industry, through close ties to the Michigan Farm Bureau.

That structural conflict of interest represents a common problem of government agencies that must meet the interests of a specific constituency and the interests of a diffuse public. Federal agencies susceptible to this kind of structural conflict of interest include the Food and Drug Administration[50] and the Federal Trade Commission.[51] The situation within the Michigan Department of Agriculture parallels that of the Atomic Energy Commission which suffered from a conflict between promoting and regulating nuclear power and ultimately led to its reorganization into two separate

agencies. [52] Such conflict can create a situation of "regulatory capture" in which the interests of the regulated industry come to dominate the actions of the regulatory agency.

The Michigan case also demonstrates how uncertain figures become "golden numbers," as Robert Socolow observed in another environmental conflict. He wrote: "A number that may once have been an effusion of a tentative model evolves into an immutable constraint. . . Apparently, the need to have precision in the rules of the game is so desperate that the administrators seize on numbers (in fact, get legislators to write them into laws) and then carefully forget where they come from."[53] An organization becomes committed to a number or a policy not only for institutional interests but also for broader social and political reasons. Protecting the number or the policy comes to represent protecting organizational integrity.

Michigan health officials also became committed to a definition of PBB contamination as an agricultural problem and not a health problem, as affecting cattle and not people. Officials recognized persons with ill health but refused to admit a connection to PBB. The State Department of Health continued to defend its position that no "PBB syndrome" existed, unable to admit publicly the uncertainties and problems of the Department's initial epidemiological survey. That position resulted in a policy that lasted three years, a policy of no medical care or assistance to farm families which had consumed large quantities of PBB-contaminated products.

The Michigan case thus illustrates two basic structural problems for public health departments: the conflicts around organizational boundaries, and the tensions between public and private sectors.[54] Chemical contamination, like many technical problems with broad social and political consequences, does not fit easily within the bailiwick of a single agency. Health problems commonly overlap with questions of agriculture, environment, labor, schools, and other areas, thereby creating complex conflicts for health departments around responsibility, coordination, and communication with other government agencies. Such conflicts around organizational boundaries represent typical problems for institutions in a complex social environment. The structural dichotomy between public and private sectors is a long-standing tension for public health departments in the United States. Private medicine has traditionally opposed public provision of medical services, except under extraordinary circumstances. While health departments are responsible for the epidemiologic investigation of environmental problems (about which private medicine has little interest), the agencies lack mechanisms to provide victims of chemical contamination with health services (which would cross the interests of private medicine). Deciding what role public health departments take toward victims of toxic contamination will remain a source of continuing tension.

Recently, on August 12, 1982, the US House of Representatives Subcommittee on Investigations and Oversight, Committee on Science and Technology, held hearings on the problem of compensating victims of toxic contamination and included a panel of witnesses on Michigan's PBB contamination. As several experts testified, bureaucratic difficulties in assisting victims of toxic contamination result in part from inadequacies of the legal system, especially tort law. The hearings discussed two bills to provide compensation to victims of toxic contamination (HR 9616 in 95th Congress and HR 5074 in 96th Congress). Those bills propose an administrative system of compensation to avoid problems created by litigation and to deal better with the uncertainty in scientific evidence on toxic contamination. Among other ideas for victim compensation discussed at the hearing were a national insurance system funded out of general tax revenues and a modified national insurance system specifically for victims of toxic contamination which would include the possibility of subrogation for provable losses (the fund could sue the responsible parties to recover its payments). While the hearings did not focus on a particular legislative proposal and did not reach a precise recommendation, the session demonstrated persistent public and political concern that the victims of toxic contamination are not receiving adequate redress from either public administration or private litigation. That concern has been heightened by recent petitions for bankruptcy filed by the Manville and UNR Corporations to halt litigation by victims of asbestos poisoning.

On the problem of disposal, state officials defined burial as the correct scientific solution, and they decided on a site without consulting local politicians or local residents. Officials sought to portray burial as a narrow technical solution, to give legitimacy to their choice of policy. But that emphasis on rapid burial had an important political dimension: to remove contaminated cattle from the public sphere as fast as possible. As Dorothy Nelkin noted about technical decisions in general, the definition of inherently political problems as technical reflects a greater value on efficiency than on democracy. "Yet technical planning limits public choice and threatens the widely held assumption that people should be able to influence decisions that affect their lives."[55] The efforts to bypass the social and political aspects of burial delayed disposal and increased the burden on farmers and, ironically, exacerbated the social and political problems of disposal. People refused to consider burial as simply a technical problem and refused to let public officials ignore the social and political dimensions.

Social Conflict and Changes in Policy

One commentator on environmental politics criticized the occurrence of conflict in "technical" decisions and proclaimed the need to control and reduce conflict.[56] The PBB case illustrates the difficulties of avoiding conflict in toxic contamination and also demonstrates important consequences of conflict in exposing uncertainties, redefining problems, and making policy makers more accountable. Conflict is especially important in changing persistent bureaucratic definitions and procedures. As Michel Crozier explained, a "bureaucratic system will resist change as long as it can; it will move only when serious dysfunctions develop and no alternatives exist."[57]

In the Michigan case, the main source of social conflict was farmers who owned cattle contaminated by low levels of PBB but who were not compensated for damages. Those

farmers constituted a relatively concentrated group who believed they suffered health problems and unfair costs and therefore organized around the issue of PBB contamination. Political controversy created by those farmers and their allies helped expose uncertainties in the definition of illness in cattle and people and uncertainties in the levels of safety. In their protests, farmers used dramatic images of death and disease—the carcasses of cattle—to get public attention, to put pressure on politicians, and to challenge the authority of official statements. As other relatively powerless groups have done,[58] the farmers learned how to use "institutional disruptions" to create power that could force changes in public policy and force concessions from public and private institutions. They also learned how to create an organization (the PBB Action Committee), how to find allies in politics and in the press, and how to use both organization and allies to work for their goals.

A public issue becomes a political controversy as affected groups seek allies but also as political entrepreneurs seek issues. The structure of political competition in a society thus influences the form and the timing of the political controversy. In the Michigan case, some Democrats used the PBB issue to criticize the Republican governor and to advance individual political careers. But their actions also provided assistance to farmers who were spurned by their traditional political patrons in the Republican party, the Michigan Department of Agriculture, and the Michigan Farm Bureau. That PBB became more of a political controversy during elections was no accident. For elections provided an opportunity for low-level farmers to gain concessions from more powerful groups in society, as Piven and Cloward concluded generally for disadvantaged groups.[58]

Conflicts over disposal involved typical siting controversies: the "not-in-my-backyard" phenomenon, and the "if it's so safe, put it in the city" response. Those conflicts raised uncertainties about the safety of underground water supplies (in burial) and the problem of air pollution (for incineration). Protests in court and in direct action compelled politicians and bureaucrats to explain, justify, and improve the technical decisions. One political solution was to export remaining carcasses out of Michigan, to export the problem to someone else's (already contaminated) backyard in Nevada.

Conflict served to make policy makers more accountable by raising the political stakes. Conflict tended to expose organizational biases, such as the connection between the State Department of Agriculture and the Michigan Farm Bureau. In response to growing controversy, both federal and state politicians organized various public hearings, some weighted to support one side and one position, others designed to hear both sides and do nothing. Policy makers spoke at all hearings and sometimes were subjected to sharp questioning, to make them at least explain publicly the basis of decisions about the contamination.

Scientists in Controversies

The popular image of the scientist is the rational problem solver, somehow not affected by emotions or values. Former EPA official Jellinek, for example, set forth that conventional notion: "When confronted with a great deal of uncertainty, [scientists] avoid drawing conclusions, and instead call for additional careful study and research."[4] Government officials need that image of the rational scientist, especially when officials are seeking a source of legitimacy for a particular policy.

The PBB case shows, however, that actual scientists respond in various ways to uncertainty, not always upholding professional ideals and scientific principles, and sometimes submitting to organizational demands and private interests. The case shows how scientists can become deeply involved in public issues and political controversies. As James B. Conant put it: "The notion that a scientist is a cool, impartial, detached individual is, of course, absurd. The vehemence of conviction, the pride of authorship burn as fiercely among scientists as among any creative workers." Conant also warned that "this emotional attachment to one's own point of view is particularly insidious in science because it is so easy for the proponent of a project to clothe his convictions in technical language."[59]

In the first nine months, when the contamination was considered Halbert's private trouble, Dr. McKean, the veterinarian for Farm Bureau Services, who worked as a company scientist, showed some of the same conflicts as a company doctor.[60] The vet followed company policy and did not report the feed problem to public officials. And in his contacts with Halbert, the vet tended to protect his company against potential claims more than help the farmer with animal problems. The company vet thereby critically contributed to the long delay in public recognition of the feed contamination. That company scientist clearly acted with a greater commitment to private organization than to professional ideals or social ethics.

Government scientists also worked under organizational constraints. In the first nine months, these scientists were limited for organizational and budgetary reasons from doing research on a "private" problem. The state laboratory that performed feed tests on mice, for example, was not designed for research, lacking adequate personnel, equipment and funding. These scientists also lacked full information about Halbert's feed problem, information held by the company which could have hastened efforts to solve the puzzle. Some individual scientists stretched rules and budgets to study Halbert's problem, but most government scientists stuck by routines in organizations not designed to identify or research chemical contamination.

Once the problem became a public issue, scientists in state and federal agencies assumed major roles in managing the contamination problem. Their analyses of the extent of the problem became limited by organizational tendencies to underestimate the problem. State bureaucracies sought to maintain total control over scientific information, and the governor's office only began to seek outside advice in early 1976. Federal scientists, such as those in the FDA, saw themselves as professionals, but they also worked under organizational constraints. The study on chronic PBB poisoning in cattle in fall 1974 remained unpublished; and the memorandum critical of the FDA herd health survey of March 1975 did not result in further epidemiological efforts.

Some scientists thus registered dissent within the organization but without pushing for a change in policy.

Nongovernment scientists who became active in the public issue often came from universities. Some Michigan scientists (Meester and Corbett) pursued epidemiological and experimental research on their own initiative, criticizing government positions, raising health issues, and providing legitimacy to complaints of farmers. Other scientists performed studies that supported positions of the private companies or public agencies involved, often with research funds from those institutions. Outside scientists with the greatest public impact were those like Selikoff, who maintained a strong scientific reputation, a prominent public presence, and an independent organizational base outside Michigan.

These comments suggest several conclusions about scientists in conflicts over chemical contamination and other technical controversies:

- Scientists figure on all sides of the issues;
- Opposing groups all seek to mobilize their own "legitimate" scientists and scientific data;
- The resolution of conflicts depends not only on the scientific information but also on the mobilization of scientists as well as supporters;
- In a polarized situation, few scientists and few scientific studies are perceived as "neutral"; even if not intentionally instrumental, scientists and studies become identified and used more by one side than another.

In the Michigan case, as in other cases of technical controversy, the more politically adept scientists had the greater impact on policy. It is misleading to view scientists as "disinterested and rational" and politicians as somehow the opposite. As a former staff member of the Presidential Science Advisory Council in the 1960s wrote: "The Science Advisor's most potent weapon was and is a reputation for clear, disinterested technical knowledge. If he does not use or understand the political process, he will be bypassed and ineffective, regardless of the quality of his technical advice."[61] The public scientist thus needs legitimacy from a neutral reputation but gains effectiveness from political action. The effective scientist in the area of public policy thus must know about the limits of scientific uncertainty, the demand for certainty by bureaucratic organizations, and the consequences of social conflict—and how to use those constraints. In sum, the scientist must know how to be a political actor.

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AUTHOR'S FOOTNOTE

On November 18, 1982, the U.S. Environmental Protection Agency, the State of Michigan, and Velsicol Chemical Corporation announced a consent judgment of $38.5 million to settle clean-up costs associated with PBB and other chemical contamination from Michigan Chemical Corporation (purchased by Velsicol in 1970). The agreement included $13.5 million to the State and $500,000 to the EPA, to reimburse public expenses for clean-up at the Gratiot County Landfill, which was used by Michigan Chemical, and to settle a $120 million suit filed in 1978 by the State to recover costs of investigating and managing the PBB disaster. According to Velsicol officials, the company had already set aside the other $24.5 million, for clean-up of Michigan Chemical's factory in St. Louis, Michigan, and of toxic waste sites used by the company, and for materials and services in the State's clean-up of the Gratiot County Landfill. State officials considered the agreement a success for accelerating clean-up at Michigan's worst toxic waste dump, for avoiding more years of litigation, and for obtaining reimbursement at one estimate of the costs of PBB to state government—thereby helping contain recent conflicts in Michigan about toxic waste dumps and PBB.