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This paper provides an overview of the development and refinement of the scientific approach to toxic waste epidemiology that began at Love Canal in 1978. It is a daunting task to summarize the metamorphosis of the epidemiologic and risk assessment methods to study the health implications of hazardous waste sites. My first experience, as a postgraduate student in 1980, was working with the Love Canal community in Niagara Falls, New York, the Center for Disease Control (CDC), and scientists from the School of Medicine and Biomedical Sciences at the University at Buffalo. We faced the problem of conducting scientific research in an atmosphere of uncertainty with no prior guidelines or established procedures. In the face of such difficulty, the participation of citizen representatives, including representatives from homeowners and renters, was extremely helpful in keeping the science in perspective to meet the needs of the community.

Dr. John Naughton led a team of scientists from the University at Buffalo School of Medicine and Biomedical Sciences and the Centers for Disease Control Bureau of Environmental Health in 1980 under a cooperative agreement to plan health studies of the Love Canal community in response to executive orders from President Jimmy Carter.[1] After two months of working with an interdisciplinary group, we were able to finalize protocols and develop a

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[1] C.W. Heath., Jr., *Assessment at Love Canal, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J.B. Andelman & D.W. Underhill, eds., 1987).

consensus on how to approach studies. Dr. Naughton chose to proceed using community participatory methods with a diverse community-based steering committee leading the discussion and developing consensus conclusions for research approaches. This participatory approach has been described as the "gold standard" toward which all federally-funded research should aspire.[2] Unfortunately, during the final stages of planning and prior to implementation, the "plug was pulled" on our funding. We were informed that the resources necessary to do the studies were not available; thereafter, money appropriations ceased. During the funding impasse, the study team enumerated each household within the Federal Emergency Management Agency's (FEMA) designated boundaries of the relocation area. By the termination of funding in March 1981, the enumeration was completed of each household, including name, age, gender, current address (in 1981) and phone number for each household member who was living at that Love Canal address on June 1, 1978. The FEMA area was comprised 1055 households and a total of 3,868 residents. Approximately 25 percent of the population was under 15 years of age, 46 percent between 15 and 45 years of age and 30 percent over age 45.

In that era, the problem lay in a lack of infrastructure at the state health department, the local health department and the federal government to respond to the complex scientific issues presented by exposure to hazardous waste sites. It became quite clear to us that there was no government infrastructure in existence for a public health response to a problem of this nature. The problem was overwhelming, for there was no established scientific approach providing concrete guidelines as to how to initiate and implement research, or what the nature of interdisciplinary research should be to address the problems we encountered.

In the years following Love Canal it became evident that the extent of the problem was unbelievably huge. The situation demanded

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[2] U.S. DEP'T OF HEALTH AND HUMAN SERVICES, BUILDING COMMUNITY PARTNERSHIPS IN RESEARCH: RECOMMENDATION AND STRATEGIES (1998).

a special public health response, resulting in the adoption of the "Superfund Program" and the establishment of the Agency for Toxic Substance and Disease Registry under the 1980 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). CERCLA's initial five-year plan provided federal dollars and authority to respond to emergencies and take remedial action at abandoned waste sites. By 1983, the Environmental Protection Agency (EPA) inventoried 16,000 uncontrolled hazardous waste sites and 406 were listed in a National Priority List (NPL).[3] In 1985, National Geographic published and mapped the list of NPL waste sites established by Superfund.[4] The number of sites was shocking, and among them Love Canal was listed. A site had to meet certain criteria to be listed: a potential for human exposure must be present; significant exposure problems related to the site must exist; or at a minimum, a significant amount of chemicals must exist with potential for exposure. In 1991, National Geographic published and mapped an updated list. Unfortunately, the number of sites had increased and only a half dozen sites had been completely cleaned up under the Superfund Remediation Program.

Recommendations regarding the appropriate scientific approaches to addressing the hazardous waste sites are varied. In 1983, Clark Heath (the CDC officer in charge of the collaboration with UB in 1980) proposed three fundamentals to consider when assessing toxic waste sites: what toxic materials are present; how human exposure can occur; and objective measurements of biological effects.[5] At issue in the recommendations was the baseline frequency of health affects. Low frequency of onset requires a large study

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[3] R. J. Caplan & G. M. Marsh, *Evaluating Health Effects of Exposure at Hazardous Waste Sites: A Review of the State-of-the-Art with Recommendations for Future Research, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J. B. Andelman & D. W. Underhill, eds., 1987).

[4] Allen A. Boraiko, *Storing Up Trouble ... Hazardous Waste*, 167 NATIONAL GEOGRAPHIC 318, 322 (1985).

[5] C. W. Heath, Jr., *Looking Back at Love Canal*, 21 ENVTL SCI. TECH. 328-331 (1987).

population, especially when attempting to detect small increases in risk. The phenomenon at Love Canal remains unique. At Love Canal a large number of people lived on or adjacent to a major hazardous site. Typically, the sites on the NPL are located in remote areas, featuring small populations living near to the site. This quandary presents the question as to how a scientist can effectively study health outcomes under different situations. A long latency period may require periodic or continuous follow-up. At that time, there were no available mechanisms to conduct such a study. Therefore, as a scientist, you must be prepared to perform such a study in the absence of the necessary means. Multiple causative factors, multiple hosts, exposures and particular health affects are not specific to particular toxic exposures or a mixture of toxic exposures. Consequently, when discussing adverse health effects, the known risk factors for each outcome need to be examined with methods available to control confounders and assess the environmental exposures of interest.

Phil Landrigan, a well-known environmental epidemiologist from Mt. Sinai, published a list in the same 1983 publication.[6] His list featured documentation of chemicals in the dump, an assessment of materials released from the dump into the environmental media, tracing possible roots of exposure, and development, when possible, of individual exposure estimates in direct biological absorption. The factors examined in his evaluation were the focus of many Love Canal debates: who was exposed, where did exposure occur, and how to obtain the available documentation. Regardless of the seemingly lack of knowledge, the Love Canal FEMA relocation was subjected to extensive testing of the soil. The EPA spent a lot of money conducting tests; however, there was little direct exposure assessment.[7] From the outset the New York State Health Department realized research was needed for a thorough understanding of the degree of exposure, particularly in the inner two rings of homes

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[6] P. J. Landrigan, *Epidemologic Approaches To Persons With Exposures to Waste Chemicals*, 48 ENVTL HEALTH PERSP. 93-97 (1983).

[7] U.S. ENVIRONMENTAL PROTECTION AGENCY, ENVIRONMENTAL MONITORING AT LOVE CANAL (1982).

directly adjacent to the Love Canal site. They realized people were continually being exposed, so an emergency declaration was issued to evacuate people from the inner two rings of homes. Today this is a basic public health response, as outlined by ATSDR's Public Health Assessment Guidance Manual,[8] but at that time this represented an unusual scenario. Procedures for addressing toxic chemical exposure from waste sites versus other types of exposures hadn't been thought of. Eventually precise definitions of sub-populations at high risk of exposure were established through the employment of specific and sensitive health outcome indicators. As we became more involved in our research, we were faced with the challenging tasks of developing specific and sensitive indicators to adequately assess the damage from exposure. Negative results should be interpreted cautiously to avoid drawing incorrect inferences.

Meanwhile, in 1987 a sentinel book was published. *Health Effects From Hazardous Waste Sites* was published featuring a comprehensive state-of-the-art review and summaries of the results of studies at Love Canal.[9] In addition, the National Research Council released their book, *Environmental Epidemiology, Public Health and Hazardous Waste*, citing specific recommendations as to what should be done and the approaches to be taken at toxic waste sites. The book provided specific details regarding the process of the physical and biological routes of transport and potential human exposure. The hypothetical disposal site resembled the phenomenon at Love Canal,

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[8] AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, PUBLIC HEALTH ASSESSMENT GUIDANCE MANUAL (1992).

[9] C.W. Heath., Jr., *Assessment at Love Canal, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J.B. Andelman & D.W. Underhill, eds., 1987); G. M. Marsh & R. J. Caplan, *Evaluating Health Effects of Exposure at Hazardous Waste Sites: A Review of the State-of-the-Art with Recommendations for Future Research, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J. B. Andelman & D. W. Underhill, eds., 1987); B. Paigen & L. R. Goldman, *Lessons from Love Canal: The Role of the Public and the Use of Birth Weight, Growth and Indigenous Wildlife to Evaluate Health Risk, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J. B. Andelman & D. W. Underhill, eds., 1987).

featuring evaporation, leaching and direct surface run-off, similar to the surface contamination of the homes in the inner two rings.[10]

What are the other potential routes of contamination? Part of the problem lies in documentation; recording how much contamination exists in the soil, how much is moving through the soil, where it is going, and the extent of the contamination in regional aquatic or terrestrial biota. Consequently, human exposure can be through direct dermal contact with the soil, ingestion of soil and water, and inhalation. There are existing sites where volatilization of chemicals off the site has created an inhalation exposure problem. Therefore, the potential routes of exposure are complex and numerous, and warrant awareness. Scientists now battle with the question: what is the potential for human exposure through these different routes?

Once you establish the pathways and discover human exposure, whether through skin contact, ingestion, or inhalation, there are a couple of possible outcomes depending upon the type of chemical the person is exposed to. Some chemicals are non-persistent (with a short biological half-life) and create acute body burdens detectable either during or shortly after exposure. The acute body burdens can lead to acute effects. For example, if an individual is exposed to lead, they may develop lead poisoning or, more seriously, long-term exposure can relate to chronic health effects such as kidney damage and high blood pressure. A number of different scenarios are possible in which one chemical can produce acute or chronic effects, depending upon its toxicity. If the chemical is a persistent organic pollutant, like dioxin, bioaccumulation may occur. Bioaccumulation and biomagnification in the food chain can lead to constant low dose exposure. Therefore, scientists must consider what chemicals exist and where the chemicals are transported, the population's reaction once exposed, and potential health effects.

A common problem with exposure data is the degree of variability, both past and present, resulting in frequent changes in

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[10] NATIONAL RESEARCH COUNCIL, ENVIRONMENTAL EPIDEMIOLOGY: PUBLIC HEALTH AND HAZARDOUS WASTES (1991).

dose and exposure estimates. Initially, the residents near a dumpsite most likely experienced significant exposure to chemical waste; for example, children may have been swimming in bodies of water near the site when the site was being contaminated through active dumping. There exists a variability regarding the persistence of exposure over time, possibly expanding over a period of decades. Perhaps interaction or simultaneous exposure to multiple chemicals is a more appropriate explanation of the Love Canal phenomena where the documented complaints were multiple outcomes in several body systems among all subgroups of the population (old and young). When confronting a site of multiple interacting chemicals, scientists battle with determining exactly what to measure. Is the peak exposure important or is a time-weighted average? Is the short-term exposure more important than life time exposure?

A common problem encountered in environmental studies at waste sites, is the high correlation between the exposures. In 1980, Dr. Naughton and I attended a meeting with the CDC regarding the future of environmental studies. During the meeting, CDC representatives challenged the accuracy of environmental studies and questioned our ability as scientists to effectively study and document the problem amidst multiple chemical interactions. Our response was that in a problem of such magnitude, 100 percent knowledge and definitive cause-effect of a specific chemical with an outcome was impossible. However, we believed the high correlation between the exposure to multiple chemicals likely demonstrated a pattern of exposure that could be related to certain health effects, indicating a public health problem. From this knowledge, epidemiologic variables and semi-quantitative exposure measures may be used to assess the problem. Our interest lies in epidemiology, the only available science that can look at multiple chemical exposures related to an outcome among human populations.

At Love Canal, scientists attempted to use indoor and personal monitors, instead of ambient monitors, to quantify what types of exposure were important, given the waste site. This presented a new problem: how to adjust for sample variation. Even the EPA was criticized for their environmental sampling scheme used at Love

Canal.[11] Critics questioned the number of samples the EPA selected, how samples were taken, and whether the methods were sufficient to look at variability of exposure across time and geography.[12]

To do a thorough quantitative assessment at one site involves a huge cost. The EPA spent eight million dollars on environmental testing at Love Canal.[13] After the samples are taken, they must be sent to a lab and put through different analytic procedures. Self-selection and confounding variables pose other problems. Non-response, incomplete follow-up, reporting errors, and reliance upon self-reported exposures all affect the accuracy of results.

In environmental epidemiology the exposure assessment and outcome measure are both critical and necessary. Consequently, it is important to establish an interdisciplinary team with an ability to run tests from acute to chronic and to measure apparent and unapparent outcomes. Symptom-prevalent surveys have been proposed at different waste sites.[14] An interdisciplinary team can evaluate symptoms, such as: rashes, eye irritation (likely related to more recent exposure) different kinds of rashes, paralysis or tremors; and diseases or disorders that are based on medical definitions, such as: abnormal reproductive outcomes, behavioral disorders, cancer, respiratory disorders, etc. There are also less apparent, more sub-clinical types of outcomes, for example: biochemical abnormalities, liver function tests, nerve conduction abnormalities. A spectrum of outcomes can be involved. The decision to examine any of the outcomes depends

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[11] R. J. Smith, *Love Canal Study Attracts Criticism*, 217 SCI. 714-715 (1982); R. J. Smith, *The Risks of Living near Love Canal*, 217 SCI. 808-809, 811 (1982); U.S. ENVIRONMENTAL PROTECTION AGENCY, ENVIRONMENTAL MONITORING AT LOVE CANAL (1982).

[12] R. L. Anderson, 98 AMSTAT NEWS 3-4 (1983); Deegan, *Looking Back at Love Canal*, 21 ENVTL SCI. TECH. 328-331 (1987); E. K. Silbergeld, Testimony Presented Before the Subcommittee on Commerce, Transportation and Tourism 76-100 (1982); R. J. Smith, *Love Canal Study Attracts Criticism*, 217 SCI. 714-715 (1982); M. R. Stoline & R. J. Cook, 40 AM. STAT. 172-177 (1986).

[13] R. J. Smith, *Love Canal Study Attracts Criticism*, 217 SCI. 714-715 (1982)

[14] L. W. Roht et al., *Community Exposure to Hazardous Waste Disposal Sites: Assessing Reporting Bias*, 122 AM. J. EPIDEMIOLOGY 418-433 (1985).

upon the contents of the dump and how people are exposed. Issues regarding outcome assessment are carefully considered in the review by Marsh and Caplan,[15] and a recent review by Tarkowski and Rolecki.[16] Seven categories of health outcomes have been identified as priority for study near hazardous waste sites: 1) birth defects and reproductive disorders, 2) cancer at selected anatomic sites, 3) immunological disorders, 4) kidney dysfunction, 5) liver function disorders, 6) lung and respiratory diseases and 7) neurotoxic effects.

Some investigators have been studying environmental worry and attempting to interpret self-reported symptom data.[17] Some of the symptom prevalent surveys that are being done around waste sites have experienced a problem with response bias, or systematic bias, that tends to cause errors in the risk assessments made.[18] If respondents are worried about environmental contamination and a subtle symptom exists that cannot be validated through a medical examination, a scientist cannot publish his/her results without an assessment of the bias. Should a scientist fail to assess the bias, the results of the study will most likely not be well received by the scientific community. This was the case with Dr. Paigen's study

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15 G. M. Marsh & R. J. Caplan, *Evaluating Health Effects of Exposure at Hazardous Waste Sites: A Review of the State-of-the-Art with Recommendations for Future Research, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J. B. Andelman & D. W. Underhill, eds., 1987).

16 S. Tarkowski & R. Rolecki, *Hazardous Wastes and Public Health: Potential Health Effects of Exposures at Levels Encountered Around Landfills*, 5 EUROPEAN EPIDEMIOLOGY MARKER 1-7 (2001).

17 M. J. Mendell & J. Lipscomb, *Interpretation of Self-Reported Symptom Data in Settings with Likely Over-Reporting Due to Environmental Worry*, 46 ARCHIVES ENVTL HEALTH 124 (1991).

18 M. J. Mendell & J. Lipscomb, *Interpretation of Self-Reported Symptom Data in Settings with Likely Over-Reporting Due to Environmental Worry*, 46 ARCHIVES ENVTL HEALTH 124 (1991); L. W. Roht et al., *Community Exposure to Hazardous Waste Disposal Sites: Assessing Reporting Bias*, 122 AM. J. EPIDEMIOLOGY 418-433 (1985).

based upon self-reported data from people in Love Canal community.[19] Even though community participation was involved, they were criticized for not assessing potential bias. There must be a balance between self-report, and how it is done, validated, and assessed. The common method to control for environmental worry in a symptom prevalence study is to assess worry about local environmental health risk and whether illness preceded such worry. Over-reporting due to worry and physiological stress affects of worry, are recommended for measurement if environmental exposure effects are to be assessed in terms of symptoms.[20] Construct reporting validity studies often use alternative symptoms, symptoms not suspected as related to the exposure in question. To determine worry, ask people if the chemicals in their environment are causing health problems; "are you worried these exposures may be making you ill?" Standardized questions have been developed. There are a certain percentage of people who do and do not worry about the chemicals in the environment. Therefore, researchers must stratify and adjust for certain demographic variables, and control for environmental worry and over-reporting by evaluating the other symptoms. Controlling for stress effects is possible, although the effectiveness remains questionable. Assuming assessment of bias is possible, Dr. Ozonoff argues that when

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[19] L. R. Goldman & B. Paigen, *Low Birth Weight, Prematurity and Birth Defects in Children Living Near the Hazardous Waste Site*, 2 HAZARDOUS WASTE & HAZARDOUS MATERIALS 209-233 (1985); B. Paigen et al., *Prevalence of Health Problems in Children Living Near Love Canal*, 2 HAZARDOUS WASTE & HAZARDOUS MATERIALS 23-43 (1985); B. Paigen & L. R. Goldman, *Lessons from Love Canal: The Role of the Public and the Use of Birth Weight, Growth and Indigenous Wildlife to Evaluate Health Risk, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J. B. Andelman & D. W. Underhill, eds., 1987).

[20] M. J. Mendell & J. Lipscomb, *Interpretation of Self-Reported Symptom Data in Settings with Likely Over-Reporting Due to Environmental Worry*, 46 ARCHIVES ENVTL HEALTH 124 (1991); L. W. Roht et al., *Community Exposure to Hazardous Waste Disposal Sites: Assessing Reporting Bias*, 122 AM. J. EPIDEMIOLOGY 418-433 (1985).

adjusting for environmental worries, scientists can document excess symptom prevalence in relation to a dumpsite.[21]

In 1980, ATSDR was established through CERCLA, but four to six years after its establishment citizens' groups and others were forced to sue the government to establish priorities for ATSDR within the Center for Disease Control (CDC), which led to the 1986 Amendments (Superfund Amendments and Reauthorization Act, SARA).[22] By 1993 the government published a public health guidance manual for evaluation of waste sites.[23] It is a detailed guidance manual for completing health assessments. Included is an overview of what a health assessment is, how to evaluate site information and detailed procedures on how to evaluate a specific waste site and respond to community concerns. The Love Canal provided valuable knowledge, in the form of experience, on citizen participation. Generally, citizens are very willing to meet and discuss their concerns. Citizen involvement is a fundamental part of an ATSDR health assessment. In determining contaminants of concern, the manual details how to identify which chemicals, at varying exposure levels, are of the utmost concern from a toxicological point of view, and how to evaluate exposure pathways among different media. From this information, public health implications are determined based upon actual health assessments.

ATSDR works in conjunction with the EPA. The EPA completes risk assessments based on the potential exposure to the toxicity of substance. The health assessment sometimes involves site-specific human monitoring data. Available morbidity or mortality data is typically evaluated. The assessment is a public health evaluation and environmental endangerment assessment combined. The

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21 D. Ozonoff et al., *Health Problems Reported By Residents of a Neighborhood Contaminated by a Hazardous Waste Facility*, 11 AM. J. IND. MEDICINE 581-597 (1987).

22 B. L. JOHNSON, HAZARDOUS MATERIALS CONTROL, ATSDR UPDATE: GOALS FOR IMPLEMENTING THE HEALTH PROVISIONS OF CERCLA (1990).

23 AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, PUBLIC HEALTH ASSESSMENT GUIDANCE MANUAL (1992).

results of this health assessment, combined with the risk assessment, exposure profile and toxicity, are used to determine the response action, a public health action plan and/or a decision to create a more thorough ATSDR health assessment. The new health assessment could include relevant epidemiology studies or establish a registry of exposed people or enrollment in health surveillance programs. The health surveillance programs act to further reduce human exposure and help determine whether the affected people should be relocated. In summary, now there are mechanisms in place through ATSDR to assist committees and local and regional governments in their decision-making process.

A couple of years ago, ATSDR located a number of sites that presented a significant and imminent health threat based on exposure pathways, a record of decision and feasibility studies. Compiling the necessary information was very time consuming, months pass before the information is gathered, interpreted and decisions made. This process is not without its criticism. Marvin Legator, from the University of Texas, is a strong and vocal critic of ATSDR health assessments. He conducted the second cytogenetic study of Love Canal, which produced negative results.[24] However, he is a strong proponent of community action and participatory research in particular. In 1993 he wrote an interesting commentary on public health policies regarding hazardous waste sites and did an analogy to cigarette smoking.[25] He recommends ending health assessments, especially those designed to be negative. Instead, he proposes channeling the money into cleaning up hazardous sites to prevent exposure. His commentary was followed by an editorial by Barry Johnson, Head of ATSDR, and M. Lichtveld.[26] They indicated that

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[24] C.W. Heath., Jr., *Assessment at Love Canal, in* HEALTH EFFECTS FROM HAZARDOUS WASTE SITES (J.B. Andelman & D.W. Underhill, eds., 1987).

[25] M. S. Legator & S. F. Strawn, *Public Health Policies Regarding Hazardous Waste Sites and Cigarette Smoking: An Argument By Analogy*, 101 ENVTL HEALTH PERSP. 154-155 (1994).

[26] B. L. Johnson & M. Litchtveld, *Superfund and Public Health Policies: An ATSDR Response*, 101 ENVTL HEALTH PERSP. 12-13 (1993).

ATSDR's approach has been created to protect public health, citing progressive improvements to the methods employed. In 1994, another editorial stated that ATSDR's assessments conducted were not adequate and responsive to community concerns and needs. Many health assessments, they stated, were predictably misleading and deceptive. They recommended evaluation of ATSDR on ATSDR-sponsored studies.[27]

With regard to participatory action research methods, participants must know the results are seriously considered. All research depends upon the subjects analyzed, especially concerning the citizens' group interest in the site's cleanup. In the Love Canal population, the homeowners and the citizens drove the research process, both scientifically and politically. Absent citizen participation, good epidemiology is impossible. Citizen involvement provides many opportunities for interaction, feedback and problem definition. There are a number of different ways citizens may influence research, but generally, the more citizen involvement, the better the results. ATSDR health assessment ideally does incorporate citizen participation. An advantage to an active citizenry is it incorporates local knowledge regarding what has occurred at the site and it capitalizes on the diversity of education. Whenever I become involved in a process like this, I learn what the citizens know. This process encourages development and links research to social action by requiring the involvement of citizen representatives. In a recent request for proposals from the National Institute for Environmental Health Services on children's interactive health centers, a community based intervention program, including cooperative studies community based studies, was mandatory. Should a proposal fail to include citizen involvement funding is denied. As I became more involved in studies on toxic waste sites, I began to realize that a major problem is the ecosystem effect. The substances leaching from the dump sites affect the neighboring population through bio-accumulation and

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[27] M. S. Legator & A. M. Howells-Daniel, *A Deliberate Smokescreen*, 49 ARCHIVES ENVTL HEALTH 154-155 (1994).

biomagnification in the food chain. Currently, I am interested in the bioaccumulation process of the persistent organic pollutants that place humans at an increased level of risk.[28] For example, a lake trout taken from Lake Ontario tests positive for dioxin at forty parts per trillion. The dioxins are in the meat of the fish, having accumulated over long periods of time. Interestingly, the Food and Drug Administration's tolerance limit for food is ten part per trillion, one trout from Lake Ontario exhibits approximately four times the recommended level. Ironically, our government stocks Lake Ontario with these magnificent fish for the sportsmen and concurrently instructs the fisherman not to eat them. This example serves as a summary of what epidemiologic studies hope to accomplish by demonstrating the potential indirect impacts of contaminated waste sites. Not only are there problems directly adjacent to a site but often there are ecosystem consequences. A number of identified sites in Niagara and Erie counties continue to leach into our environment, creating a need to examine the pathways of exposure, which may ultimately be a significant route for human populations.

Twenty years ago, the Love Canal community opened the eyes of fellow citizens, government representatives, health officials and environmental and health scientists to the social, political, economic and public health consequences of the short-sighted hazardous waste disposal practices of the industrial-boom era. May we all continue to learn from the tragic legacy of the Love Canal environmental disaster.[29]

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[28] John Vena et al., *The New York State Angler Cohort Study: Exposure Characterization and Reproductive and Developmental Health*, 12 TOXIC IND. HEALTH 327-334 (1996).

[29] More information on Love Canal and research resources can be found at the Science and Engineering Library of the University of New York at Buffalo *at* http://www.ublib.buffalo.edu/libraries/projects/lovecanal/index.html.