HEALTH EFFECTS OF

HAZARDOUS WASTE INCINERATION...

MORE OF THE REST OF THE STORY

AN UPDATED REVIEW OF THE SCIENTIFIC BASIS OF ALLEGED ADVERSE HEALTH EFFECTS OF HAZARDOUS WASTE INCINERATION

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ABSTRACT

As with all environmental exposures, the potential impacts of hazardous waste incineration on human health and the environment should be addressed scientifically and thoroughly. Making a scientifically valid connection between operation of an incinerator and resulting disease within a population is a difficult undertaking, requiring the combined efforts of toxicologists, epidemiologists, environmental chemists, physicians, and other disciplines. Concerns regarding the potential impacts of incineration needed to be addressed and communicated, both accurately and effectively, if the actual risks of incineration are to become widely understood.

This paper reviews past allegations of adverse health and environmental impacts associated with hazardous waste incinerators, and reviews "the rest of the story" to describe the outcome or status of each case in question. This review includes only formal studies of actual data or measurements of health impacts, and excludes any discussion of EPA-driven health risk assessments based on estimated emissions, dispersion, and impact data. Particular emphasis is placed on those cases included in Chapter 5 of Greenpeace's report, "Playing With Fire," which allege adverse health effects due to hazardous waste incineration. The facilities reviewed include those in the United Kingdom, Louisiana, and Arkansas; additional reports of facilities in Germany, Texas, and North and South Carolina are also discussed. The general finding is that no clear evidence of adverse impacts to human health could be determined through past scientific investigations, although many studies are still underway.

INTRODUCTION

In 1990, Greenpeace published a report about waste incineration entitled "Playing with Fire", authored by Costner and Thornton (1). Chapter 5 of this report is a compilation of frequently-cited allegations of health and environmental impacts of five facilities which incinerate hazardous waste, which the authors describe as "among the few cases where formal or informal health surveys have been conducted". If true, these reports would indicate an important limitation to the use of incinerators due to the potential for adverse effects to local residents.

The purpose of this paper is to review the scientific basis of these five case studies. A complete description for each of Greenpeace's five case studies from the "Playing with Fire" report is quoted under the heading "Allegation." This is followed by a description of the available information in each case, reviewed under "Review of Literature" and summarized under "Conclusion."

CASE #1: UNNAMED INDUSTRIAL WASTE INCINERATOR, COPPULL, LANCASHIRE, U.K.

Greenpeace Allegation: *"One recent British epidemiological study documented a "marked concentration" of larynx cancer cases among adults in a community within two kilometers of a commercial waste incinerator (A. Travis, 1989)."*

Review of Literature: The cited reference (2) refers to a newspaper article published in The Guardian by Alan Travis, a British newspaper reporter. The newspaper article quoted a presentation made by Anthony Gatrell, a professor in the Lancaster University Department of Geography, at the British Institute of Geography's annual conference in January 1989. In his presentation at the conference, Gatrell noted an unusual *distribution* of four cases of laryngeal cancer in an area of a village located near a small, unnamed industrial waste incinerator. The facility was located in or near the small town of Charnock Richard, Coppull, in Lancashire, U.K., and operated from 1972 to 1980. According to a subsequent paper by Gatrell and Lovett (3), the facility processed liquid wastes, primarily solvents and oils. It was not a commercial incinerator, as reported, but an incinerator used to destroy industrial wastes generated on site.

Gatrell was quoted from his conference paper that the findings demonstrated a "marked concentration" of four cases of laryngeal cancer in the southwestern portion of one particular village, all of which were located within two kilometers of the unnamed incinerator. Gatrell's presentation noted the distribution of laryngeal cancers as being "sufficiently unusual" to warrant analysis, and recommended that "rigorous statistical analysis" be done to better assess these data.

Following his presentation, Gatrell and another researcher were commissioned to study cancers in Lancashire and to address concerns about the possible health impacts associated with the incinerator. Gatrell subsequently analyzed these distribution data himself and published them in a waste management book titled Waste Location: Spatial Aspects of Waste Management, Hazards, and Disposal (3).

In their analysis, the authors studied 6,200 cancer cases diagnosed between 1974 and 1983 and found 58 cases of cancer of the larynx over that 10-year period. Of these, four cases of laryngeal cancer were located near the incinerator. In these cases, Gatrell and Lovett found "a statistically significant association with proximity to the incinerator," although the incinerator could not be identified as the cause of this association due to a lack of other important information.

In assessing whether there was also an increase in the *incidence* of laryngeal cancer, Gatrell and Lovett reported "no statistically significant excess" cases of laryngeal cancer (as reported in (4)). The number of cancers that would have been statistically expected was not reported. Additional statistical analyses of the incidence of cancer cases were performed by other researchers and published in an article in The Lancet (4). The authors found that "the incidence of lung and laryngeal cancer in individuals living near the incinerators was not significantly greater than that expected in the population."

To determine whether the 58 reported cases of laryngeal cancer are statistically significant, one compares the number of cases of laryngeal cancer expected in a population with the number of cases actually observed. No British data were provided in these reports, but the reported cases in Lancashire are below the number which would be expected using U.S. cancer statistics.

The American Cancer Society (5) estimates expected new cancer cases based on data from previous years. They estimate that 12,500 of the expected 1,130,000 U.S. cases of cancer in 1992 (excluding non-melanoma skin cancer) will be cancer of the larynx. Assuming U.S. cancer incidence rates are basically similar to those in the U.K., approximately 69 cases of cancer of the

larynx would be expected out of 6,200 cases of diagnosed cancer. Thus, the number of cases of cancer of the larynx reported by Gatrell (58) was actually less than would be expected by the American Cancer Society, with or without the presence of the incineration facility. Some caution in extrapolation is advised due to differences between the British and US cultures; however, the calculations do support the conclusion of Elliott *et al.,* i.e., that the observed number of cases of laryngeal cancer were not greater than expected.

In summary, Gatrell and Lovett stated:

> *"Clearly, in the absence of additional information it is foolish to claim that living near the incinerator has 'caused' cancer of the larynx. We do not have information on the residential histories of the cases, or details of where they worked...We have no information on the latent period, inevitably variable for different individuals, over which the cancer will have developed. This may have been five years (which would of course strengthen the argument for causation) or twenty-five years (well before the incinerator commenced operation). Further, we have no details about smoking histories, alcohol consumption [the two principal known risk factors for laryngeal cancers, per Elliott et al, 1992], or other risk factors for individuals. Nor do we have background environmental information on air pollution..." (3)*

Thus this study would not be considered a true epidemiological study, contrary to claims made by Costner and Thornton (1)(but not Gatrell).

Other limitations to their study included:

- possible lack of peer review prior to publication
- no inclusion of any raw or statistical data or calculations
- lack of other demographic information (sex, age, etc.)
- lack of meteorological information to determine whether the incineration facility was upwind of the affected population
- lack of information with regard to the number of cases of laryngeal cancers that would be expected in the population.

The authors recommended further research to determine the causation of these cancer cases.

Conclusion: Costner and Thornton cited an unreferenced newspaper article as a primary source of information, which does not provide sufficient information to assess these allegations. Furthermore, using one newspaper article as the primary (and only) source of data does not meet basic standards of scientific review protocol.

Two studies of this site were found in the published literature. The authors of one study found a statistically significant *distribution* of laryngeal cancer, assuming the distribution of laryngeal cancer mirrors that of lung cancer; however, the cause of this increase could not be attributed to any given source (including the incinerator, specific occupations, personal habits, or other

causes) without significant additional information. Neither study found an increased *incidence* of laryngeal cancer in the Lancashire population.

CASE #2: ROLLINS HAZARDOUS WASTE INCINERATION FACILITY, ALSEN, LOUISIANA, USA

Greenpeace Allegation: *"A health survey in Alsen, LA, site of a hazardous waste incinerator operated by Rollins, Inc., found three cancer deaths in one block of nine houses, with two children in one family suffering from cancer. A 1980 health survey found 80 percent of the population suffering from headaches, respiratory ailments, and sinus problems. A more recent survey found asthma in 20 percent of the community as opposed to 7 percent in a control group (Connett, 1990)."*

Review of Literature: The reference cited for this study (6) refers to Ellen and Paul Connett, editors of the Waste Not newsletter which is openly opposed to incineration.

The first "health survey" Costner and Thornton cite is not in fact a health survey according to the standard definition of the term, but refers to questions asked of Florence Robinson, Assistant Professor of Biology at Southern University (who reportedly conducted the survey), by William Sanjour of the U.S. Environmental Protection Agency (6). Waste Not quotes Sanjour as stating his survey was inherently biased: "I make no claims for the scientific accuracy of such a small survey, especially since it was taken from people who are actively opposed to the site" (7). Neither Waste Not nor Robinson cite the source of the information regarding the three cancer deaths in one block of houses or the two childhood cancer cases in one family. Further, from an epidemiological standpoint, blocks of houses, etc., are not a usual or informative way of expressing incidence rates, which are necessary to determine impacts from an incineration facility.

The last two "health surveys" cited by Costner and Thornton are mentioned by Robinson in the same interview with Sanjour. In the interview, Robinson cites one "survey", conducted in 1980, that "showed that 80% of the population suffered from headaches, respiratory ailments, and sinus problems". The other "survey" was conducted by Robinson and reported that "20% of the community suffered from asthma as compared with 7% from a control group." The supporting data for these "surveys" have not been provided, despite repeated requests for the original data and results, and the number of people interviewed versus number of controls. In addition, the data have not been published in the scientific literature or any other form readily accessible for public review.

Conclusion: Costner and Thornton cite an interview in a newsletter as a primary source of scientific information, not generally considered a valid sole source of data. The originator of the "health surveys" cited in the interview raises serious allegations, but declines to provide supporting data. With no information available to support these allegations, there is no opportunity for scientific or peer review necessary to validate them.

CASE #3: RECHEM CHEMICAL WASTE INCINERATOR, BONNYBRIDGE, SCOTLAND

Greenpeace Allegation: *"In Scotland, a study found an increase in the frequency of human twins in the areas most at risk from air pollution from chemical waste incinerators. During the same time and location, a "dramatic increase" in twins among dairy cattle was documented. Scientists conducting the study linked this effect to incinerator air emissions of "polychlorinated hydrocarbons, some of which have oestrogenic properties" (8)."*

Review of Literature: The findings in this article cited by Costner and Thornton (8) have become a topic of widespread discussion in the medical and popular literature. There are several major, unverified assumptions that the authors make in this report, such as: 1) polychlorinated hydrocarbons (which the authors call PCHs) were released in sufficient quantities by the incinerator, 2) these PCHs were absorbed in sufficient quantities to produce physiological effects, 3) PCHs have significant estrogenic properties, 4) estrogen levels are significant determinants for the frequency of twinning, and therefore 5) incineration can cause twinning. All of these assumptions have been challenged to varying degrees.

Further, the increased twinning in the human and animal populations (which is apparently limited to one year and one dairy farm) is based on the assumption that the increase is due to air pollution in general and the Rechem incinerator in particular (which is clearly not shown). This is a study of geographic clustering, without measurements (actual or estimated) of chemicals in air, feed, or other media -- data which are necessary to establish causal association or correlation with the incinerator. Whether, and to what degree, PCHs are estrogenic has not been established. Estrogen levels may be elevated in women with twins, but it is not known whether high levels of estrogens *cause* twinning or are a *result* of twins in utero, or neither. (9).

Most importantly, the study's authors do not link the twinning to incinerator air emissions of PCH's, as claimed by Costner and Thornton. In fact, the authors caution that "although the present findings were consistent with the hypothesis that environmental air pollution may have affected obstetric parameters of the local populations of people and animals, it would certainly be premature to attribute causality to this association between air pollution from incinerators and twinning" (9).

The original 1988 findings of Lloyd *et al*. have been debated in the medical literature. P.W. Jones makes a number of arguments questioning the basis of Lloyd *et al.*'s 1988 study (10). Specifically, Jones demonstrates that there is no established twinning effect that can be linked to the presence of the Rechem incinerator. First, Jones offers that the published concentrations of PCH's are indistinguishable from concentrations normally found in UK soils. Further, these "normal background" levels have not decreased since the Rechem chemical waste incinerator was closed in 1984, likely indicating the incinerator was not a major contributor of these compounds to the local environment. Indeed, automobile emissions and coal combustion are by far the greatest sources of PCHs in the environment; cigarette smoke is a primary source of PCH exposure to individuals.

Second, Jones' examination of the human twinning rates presented by Lloyd *et al.* shows a "*random* occurrence of marginally raised rates." Investigation of the data for the 14 areas studied reveals no consistent twinning trend over time and Jones feels that it is "difficult to establish whether human twinning is raised in the general area or not."

Jones also points out that while the data presented for twinning in cattle may appear to establish a real occurrence, it also occurred during and after periods in which the Rechem incinerator operating but was not handling PCHs. Assuming for the sake of argument that PCHs do have estrogenic properties and that estrogens do cause twinning, the incinerator would have had to be burning PCHs to have caused this effect. This, in conjunction with the awareness of PCHs being indistinguishable from background levels, lends support to the argument that there is no causal association between a random occurrence of marginally raised twinning rates and operation of the Rechem incinerator.

A major government study was commissioned in response to concerns raised by farmers in the Bonnybridge area, who had reported "raised levels of abnormalities, stillbirths, and unexpected deaths in cattle" (3). This study, the Lenihan Inquiry Report, was unable to confirm any link between environmental pollution and health problems with cattle, and "their report published in 1985 cleared Rechem and dismissed links between morbidity at Bonnybridge and incinerator emissions" (11,12). However, researchers at Dundee University have been critical of this report and have alleged adverse health effects due to the combination of heavy metals and PCHs in soil near the plant (3).

Conclusion: A 1988 report alleges increased twinning in human and animal populations may be due to emissions from a hazardous waste incinerator. In fact, the report demonstrates that only in 1980 is there a clustering of animal twinning in a specific geographic area -- one farm. Costner and Thornton quote misleadingly from the initial report of twinning, and make no mention of the several other studies that essentially discredit the hypothesis linking the Rechem incinerator to twinning. No actual or estimated concentration data are provided to show a correlation between exposure to facility emissions and twinning in the populations, and the authors of the twinning report say it would be "premature to attribute causality to this association between air pollution from incinerators and twinning". At least three major government reports, as well as articles in the medical literature, have provided data which dispute the conclusions of the claims made by Costner and Thornton.

CASE #4: ENSCO HAZARDOUS WASTE INCINERATION FACILITY, EL DORADO, ARKANSAS, USA

Greenpeace Allegation: *"A physician's survey in El Dorado, Arkansas, site of ENSCO's hazardous waste incinerator, found "a high rate of cancer in the community." For example, the overall cancer rate was 2.7 times higher than the normal rate for communities of similar size. Furthermore, there are six cases of Guillian-Barré [sic] syndrome, a rare disease with a near-zero incidence expected in a community of this size (Connett, 1990)."*

Review of Literature: As with Case #2 above, this reference is to the Waste Not newsletter published by Paul and Ellen Connett. Similar to Case #2 (see above), the "physician's survey" presented about the ENSCO hazardous waste incinerator consists entirely of William Sanjour's half-page interview of one person, Dr. Vasan, reportedly a cancer specialist whose location and affiliation are unknown. As with Case #2 above, Sanjour states in his interview, "I make no claims for the scientific accuracy of such a small survey, especially since it was taken from people who are actively opposed to the site." (7).

The information presented in Waste Not is based on Vasan's personal opinion of local economic conditions and plant operations. In the only comment regarding health impacts, Vasan declares there is a "high rate of cancer in the community" as well as an excess number of cases of Guillain-Barré syndrome, then states these data were collected "by the local citizens, not by the health authorities". No additional data are provided in support of this allegation of increased rates of illness.

In response to resident concerns regarding the potential for adverse health effects due to the ENSCO hazardous waste incinerator, the Arkansas Department of Health and the Arkansas Department of Pollution Control and Ecology conducted nine health and environmental studies of the El Dorado, Arkansas, area in 1987 and 1988 (13). The following results were found:

- Air monitoring during ENSCO's trial burn for EPA showed a 99.9999% destruction efficiency for PCBs. U.S. EPA certified ENSCO for their petitioned increased feed rate in February 1983.
- In a Health Hazard and Evaluation Report that the National Institute of Occupational Safety and Health (NIOSH) conducted at the ENSCO facility, all but one of 41 PCB air concentration samples collected exceeded the NIOSH recommended exposure limit of 1 ug/m^3. Surface wipe samples had concentrations of PCBs, PCDD, PCDF, and TCDD in excess of NIOSH guidelines. Of the blood serum samples taken, none were in excess of Occupational Safety and Health Administration (OSHA) standards for PCBs. However, NIOSH reported that "the environmental and medical data documented excessive exposure to PCB, and the environmental data documented the presence of PCDD and PCDF." It appears that onsite waste storage and handling practices, rather than the incineration process itself, may have been the cause of these increased exposures.
- Deaths due to all causes in Union County, Arkansas, have been less frequent than expected. Deaths due to cancer have been equal to the expected number (based on U.S. mortality rates).
- In assays of human serum PCB, PCB levels in blood of sampled residents were not higher than would be expected in background levels in the general population.
- PCB levels were measured in fish at sites in close proximity to the ENSCO facility. The concentrations found in the El Dorado samples were well below the U.S. Food & Drug Administration's allowable level of 2.0 ppm in edible fish.
- In a study of school absenteeism in El Dorado, the Department of Health cited no significant difference in annual average school attendance as compared to two other similar communities.

Guillain-Barré syndrome has been found to be associated with an infection prior to onset, and vaccinations for poliovirus (14) and swine influenza (15). There are no reports in the literature of any association with a chemical pollutant. (16)

Conclusion: As with the prior Connett report of interviews conducted by William Sanjour (see Case #2), several allegations are made which cannot be substantiated through any available data. Further, Costner and Thornton do not mention the other studies available through various federal and state government agencies on the ENSCO facility, all of which directly refute these claims of increased adverse health effects and cancer rates.

CASE #5: MSP AGGREGATE KILN BURNING HAZARDOUS WASTE, AMELIA, LOUISIANA, USA

Greenpeace Allegation: *"In Amelia, LA, where an aggregate kiln owned by Marine Shale Processors burns commercial hazardous waste, five cases of childhood neuroblastoma, a rare cancer of the neural tissue, have been diagnosed in a small community in which near-zero incidence would be expected. These cases have not been definitively linked to the operation of the incinerator" (McGill 1989).*

Review of Literature: The MSP facility has been widely reported in the popular press due to controversies surrounding the facility's management and operational practices. The document cited by Costner and Thornton (17) is a newspaper article in the former Baton Rouge State Times, now called the Baton Rouge Advocate. Both the newspaper article and Costner and Thornton state that these cases have not been definitively linked to the operation of the incinerator. In fact, these cases of neuroblastoma have been determined *not* to be associated with the facility.

For example, a study by Louisiana State University (LSU) of the neuroblastoma cases notes that "the cancer is usually thought to originate before birth and that three of the [five] stricken children were born before Marine Shale began operating" (17). The LSU study also concludes that "environmental exposures such as drinking water source, residential proximity to industry and pesticide treatment were very similar for cases and controls from the same geographic area and did not suggest excess exposure among the case series." (18).

On March 12, 1992, the U.S. Department of Health and Human Services released for comment its health assessment of Marine Shale Processors in Amelia, Louisiana (19). They conclude that there was an excess number of neuroblastomas in the area from 1986 to 1987. Neuroblastoma has not been consistently linked to any environmental agent. The report also concludes that in the absence of a specific exposure to test, it is not possible to link or not link these cases with any single facility. Further, close examination of the environmental and potential human exposure pathways typically indicates contamination [at MSP] is below levels of health concern.

The DHHS report further notes "St. Mary and surrounding parishes have higher than expected reported rates of congenital malformations. These rates were elevated prior to the facility going

on line." Information sought on neuroblastoma reveals that "here are some familial aggregations of the disease, suggesting the potential of inherited susceptibility."

Conclusion: As with the other four cases presented by Costner and Thornton, the often-repeated suggestion that the neuroblastoma cancers were caused by proximity to a hazardous waste incinerator is either refuted or not supported by available studies.

In reviewing the Greenpeace allegations and others in the activist literature, several common elements become apparent:

1) Most of the reports are based on single newspaper articles, activist newsletters, interviews with admittedly biased respondents, and other secondary or inappropriate sources of information which do not withstand scientific scrutiny.

2) Research studies are quoted incompletely or out of context. Often the original point made by the researcher is the exact opposite of the impression left by Costner and Thornton.

3) In four out of five cases, no data were supplied to substantiate the claims. Unsubstantiated allegations should not go unchallenged.

4) A relatively small group of people appear to be consistently generating most of the allegations.

5) The format of the allegations tends to be similar; often just the name of the facility changes.

6) The same few individuals tend to repeat the same allegations about the same facilities, even after the allegations have long since been proven incorrect.

Other Reviews of "Playing With Fire"

This paper's conclusions are consistent with other reviews of the overall Greenpeace report, provided by Focus Environmental (20), ETI (21), Santolieri *et al*. (22), and Clement (23).

CASES #6-9: PENDING NORTH CAROLINA AND SOUTH CAROLINA STUDIES

In May 1993, five papers (in addition to an earlier version of this paper) were presented on the subject of adverse effects of hazardous waste incineration at the International Congress on the Health Effects of Hazardous Waste in Atlanta, sponsored by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), a part of the Centers for Disease Control and Prevention (CDC). The oral presentations described the status of ongoing investigations in to the public health and occupational impacts of several incineration facilities in North and South Carolina, including several hazardous waste incinerators, as well as a biomedical incinerator and a municipal waste incinerator. The three public health studies were largely based on community questionnaires.

The proceedings of the conference have recently been published (24). Presented here is the written information provided on each study thus far, supplemented by personal communications with the authors.

CASE #6: THREE STUDIES OF THE CALDWELL, NORTH CAROLINA, FACILITY

A. PUBLIC HEALTH IMPACTS

In their community survey/questionnaire, Straight *et al.* (25) of the Agency for Toxic Substances and Disease Registry (ATSDR) focused on the potential adverse respiratory effects associated with the operation of the Caldwell hazardous waste incinerator in North Carolina, which had reportedly operated at twice the feed rate provided in its design specifications for eleven years (1977-1988). This plant has been widely reported to be improperly operated, as evidence in part by the extreme waste feed rates, and was closed in 1988.

In July 1991, the ATSDR conducted a "cross-sectional symptom and disease prevalence study of 713 residents living within 1.5 miles of the Caldwell site, and of 588 residents of a comparison area" about 8 miles away. The study included a questionnaire regarding the residents' respiratory, musculoskeletal, neurological, irritative, and other symptoms and diseases.

Residents living near the incinerator reported more respiratory and neurological symptoms and diseases than residents not living near the incinerator, although neither direction nor distance from the incinerator seemed to play an important role in the nature and magnitude of reported symptoms. This may reflect the inherent difficulty in conducting studies of this type. Correlating the severity of reported disease with distance from the incinerator would be an important piece of evidence to tie incinerator emissions with reported offsite effects.

Finally, when the questionnaire results were compared to physician reports and hospital admission records, there was no difference in prevalence of diseases between the Caldwell community and its control area (26). However, it is likely that occupational exposures and effects were of greater concern at the Caldwell site than offsite impacts to local residents; no high levels of contaminants were found in offsite soils, the contaminated groundwater plume from the site had not yet reached sources of drinking water, nearby dairy cattle had lead and dioxin levels below normal published values and consistent with other non-exposed cattle nearby, and there were not sufficient data to be able to reconstruct the direction of the stack emissions from the closed plant. (25,26).

B. OCCUPATIONAL IMPACTS -- KAWAMOTO STUDY

The conference reports also included two occupational studies, both of which went well beyond questionnaires to include medical and psychological evaluations to help correlate worker symptoms with facility exposures. Kawamoto (27) of the National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention (NIOSH/CDC) reported on the occupational effects to workers at the Caldwell incinerator in North Carolina, operating at twice

its designed capacity (see discussion of Straight *et al.* above). The facility has been widely reported to have been improperly managed and was subsequently shut down. Three employees had reported heavy direct skin contact and inhalation exposures to hazardous waste materials, and employees at two other hazardous waste facilities owned by the same business group had also reported similar health problems. "These conditions were reported to persist and worsen even after employment at the facilities had ceased."

In this study, NIOSH investigators (including physicians) evaluated 14 former employees reported to have neurologic problems, in order to develop a basis for designing an epidemiological study of the larger group of employees. All participants had reported a variety of non-specific symptoms (that is, they could be easily caused by any of a number of factors, including, but not limited to, chemical exposures), particularly increased response to hyperventilation. The purpose of the study was to see if there was any consistency among the symptoms that would help investigators associate the workers' exposure with subsequent effects. However, there was no consistent set of symptoms among the employees that would allow the basis for designing what investigators should look for in a larger study.

The investigators then offered screening examinations to all current and former employees to identify effects in the larger group that might have been missed in the smaller group. Despite attempts to involve as many employees as possible, only 17% of all 313 current and former employees elected to participate, and only half of the 108 confirmed appointments (54) arrived for the examination. Of these 54, no evidence was found of particular neurologic disorders.

C. OCCUPATIONAL IMPACTS -- STOPFORD STUDY

In the second study of occupational impacts, Stopford *et al* (28) clinically evaluated 29 workers from three hazardous waste incineration facilities in western North Carolina, the Mitchell and Caldwell plants and one other the author declined to identify (29). The waste of primary concern at the Mitchell plant was reportedly waste torpedo fuel. It is not known how many of the workers came from each plant.

This abstract provides the most compelling information to date on the potential for adverse occupational effects due to improper waste handling. All workers reported symptoms of "nausea, headache, dizziness, instability, and a feeling of being intoxicated associated with recurrent acute exposures from leaks, spills, or entry into contaminated confined spaces. According to the authors, "persistent neurologic problems dominate the clinical picture"; in addition to measurable physiological effects, psychological problems from sleep disorders to homicidal ideation were apparent, and 14 out of 14 workers tested had impaired memory, among other problems. This investigation was hampered by a low participation rate and a lack of a control group, and is expected to continue. (30)

CASE #7: MITCHELL SYSTEMS, NORTH CAROLINA

See discussion of this facility under Case #6C.

CASE #8: PUBLIC HEALTH IMPACTS IN THREE NORTH CAROLINA INCINERATOR COMMUNITIES

Rothenbacher *et al.* (31) of the University of North Carolina surveyed 400-500 households in three unidentified North Carolina communities to investigate possible respiratory effects in residents living near waste incinerators (hazardous, biomedical, and municipal). The questionnaire asked residents to self-report their chronic respiratory symptoms, demographic characteristics, respiratory hypersensitive conditions, smoking habits, sources of indoor air pollution, occupational exposures, and possible confounding variables. Three matched, control communities not near incinerators were also surveyed.

According to the authors, the "results showed the essential importance of matched analysis" as the prevalence of possible risk factors were higher in the control communities than in those living near incinerators. The authors reported "prevalence of lower respiratory diseases, lower and upper respiratory symptoms, asthma, and other respiratory hypersensitive conditions" in the communities living near the incinerators. These results were not reported in press summaries of the conference, such as the Science News article discussed below. This survey is Phase I of a three-year study.

CASE #9: PUBLIC HEALTH IMPACTS OF THE THERMALKEM INCINERATOR, ROCK HILL, SOUTH CAROLINA

Feigley *et al.* (32) of the University of South Carolina surveyed two communities in South Carolina. One was "exposed to the plume of a hazardous waste incinerator" (the Thermalkem plant); the other community was used as a control.

Telephone interviews were conducted with 900 respondents, asking about their respiratory symptoms and diagnoses, smoking habits, occupational exposures, and their subjective assessment of environmental risk. The authors report: "Preliminary analysis reveals significantly higher prevalence of respiratory symptoms, particularly morning cough and phlegm/mucus in the exposed community, but no significant differences in the prevalence of reported physician diagnoses of respiratory conditions...However, residents in the exposed community were more than 10 times more likely to report concern over health problems caused by chemicals in or near their home".

This conclusion points out the deficiencies of questionnaires and the confidence one may have in their results, such as interpreting the significance of increases in self-reported symptoms when these increases are not corroborated by medical examination. The possible influence of a ten-fold increase in concern about chemicals in or near their homes on the overall reporting of symptoms was not assessed. Finally, as discussed in the report of the Caldwell incinerator (26), recall bias is inherent in all retrospective studies and is of particular concern in cases involving well-publicized exposures.

Press Review of Above Studies

These five papers were reported in Science News shortly after the conference (33). Interestingly, the conclusions given by the Science News article were largely opposite of those reported by the presenters, and gave the incorrect impression -- beginning with its title "Hazardous Incinerators?" -- that significant adverse impacts of incineration were being reported in these papers: "...Many communities have expressed concerns about the health risks those [hazardous waste incineration] facilities might pose. Now, epidemiologic studies add weight to those concerns by linking respiratory and neurologic problems to working at or living near such plants."

The article reported at length about the "negative" results of self-reported questionnaires, without also citing the conflicting or "positive" results reported by the presenters, such as higher prevalence in control communities, or statistical insignificance of some data, or lack of medical corroboration of the reports, or lack of significant adverse effects clearly attributable to incineration despite some questionable operational practices. That the article was not a balanced presentation of the data only heightens confusion surrounding an already poorly understood issue.

As a result, as reported by Woodford (30), "these reports are already being cited by environmental [activist] groups as proving that life around an incinerator is unhealthy. They could more accurately be described as studies of poorly operated facilities that did not take proper safety and health precautions." We agree. It is clear that not all incineration facilities are operated in compliance with regulations or basic safety precautions, and efforts should be made to ensure compliance at these facilities or close them if these standards cannot be met. It is also clear that these facilities do not represent the majority of combustion units, many of whom welcome increased enforcement of regulatory and permit requirements to ensure basic industry standards are met.

It could not be determined from these initial reports that exposed residents are either at greater risk, or at no risk, of increased effects from incinerator emissions. As many of the authors indicate, much work needs to be done in the public health studies to correlate individual reported symptoms with specific exposures to plume concentrations or specific emissions from incineration facilities, either measured or estimated. Equally difficult is overcoming the inherent difficulties of retrospective questionnaires to develop strongly supportable, defensible conclusions.

The fact that one year has passed since the public presentation of these papers without publication would seem to indicate the results are still somewhat inconclusive, or at least do not indicate a major current or pending health hazard about which the public health community should be informed. The published versions of these reports should be helpful in independently evaluating the initial interpretation of the authors.

CASE #10: EXPOSURE STUDY OF A TEXAS CEMENT KILN BURNING HAZARDOUS WASTE

A unique study of an alternate hazardous waste combustion device, a cement kiln, provides useful data of interest to those assessing the health effects of high-temperature combustion of hazardous waste. Beginning in 1991, an extensive, three-year study was undertaken to measure the concentrations of chemicals in the environment of Midlothian, Texas. Midlothian is the site of a cement plant which is permitted to burn approximately 100,000 tons of hazardous waste each year -- more than any hazardous waste incinerator currently in operation in the US. The study was conducted entirely by the former Texas Air Control Board (TACB), forerunner to the current Texas Natural Resource Conservation Commission (TNRCC), in response to widespread allegations about adverse impacts due to emissions from the plant, which destroys organic waste at temperatures approximately twice that of hazardous waste incinerators.

At last count, approximately 1,000 samples had been taken of the ambient air surrounding the facility; the soil, water, hay, etc., surrounding the facility were also sampled. These samples were analyzed for one of 150 or so different chemical compounds, resulting in over 6,000 data points of ambient air concentrations which were compared against the state's Effects Screening Level (ESL). The ESL is considered a "tool", not a standard, for screening data for further evaluation. In addition to health effects, ESLs consider odor, impacts to vegetation, and corrosion. According to the state, if predicted or measured airborne levels of a certain chemical do not exceed its screening level, they do not expect any adverse health or welfare effects. The ESLs are approximately one one-thousandth of applicable federal occupational standards or guidelines.

The cement plant is not the only source of emissions in the Midlothian area. The samples measured not only the residual emissions of 100,000 tons of hazardous waste from the plant, but also emissions from a steel mill and a major highway adjacent to the facility, two other cement kilns within three miles, and a free trade zone nearby preparing several thousand cars for overland transport.

Of the 6,000 or so data points of ambient air, one analysis of carbon disulfide was found to exceed the state ESL. It was taken upwind of one of the cement kilns that was not in operation on the day the sample was taken, and was thought to be due to unspecified household activity near where the sample was taken. All other samples were either below the ESL or below the analytical reporting limit.

The TACB subsequently issued memos and made presentations to the residents of Midlothian and Dallas, concluding "no adverse health effects" would be expected from exposure to the measured concentrations. This conclusion was repeated by the successor agency to the TACB, the Texas Natural Resource Conservation Commission (TNRCC), which in 1995 issued a press release stating the following:

> "After years of conducting in-depth environmental assessments in the Midlothian area, the TNRCC has concluded that emissions from industrial activity in Midlothian

pose no health threat to area residents. The Texas Department of Health has reviewed all of the TNRCC's data and agrees with that conclusion." (34)

A final report has not been published as of this writing, although interim report is available (35).

CASE # 11: MEDICAL ASSOCIATION REVIEW OF SEVERAL MSWI FACILITIES

The most recent comprehensive review of incineration health effects was published by the Science Advisory Board of the German Federal Union of Physicians (36). Although focused on incineration of municipal waste, the report included a broad review of the health impacts of incineration in general. With regard to reports of adverse health effects due to incineration, the report stated in part:

> "...occasionally expressed claims that certain illnesses, such as deformities and cancer cases, occur frequently in the region surrounding existing waste incineration facilities, have not yet been able to be confirmed or verified. Individual observations are not sufficient to support causal connections...According to our best available knowledge, none of the reported illnesses can be causally linked with emissions from waste incineration facilities." (36)

SUMMARY AND CONCLUSIONS

Excessive environmental pollution from mismanaged waste has been known to cause significant adverse effects to humans, animals, and the ecosystem. Attempts have been made to reduce and prevent these pollutants through better waste management practices. Incineration is one such practice, which seeks to prevent adverse health impacts to future generations by permanently destroying waste and without increasing risk to those living near incineration facilities in the process. As with any industrial process, however, proper design and operation are important requirements to ensure the facility can be operated safely. Any technology which cannot be managed safely should not be considered acceptable.

This paper reviews the scientific basis of past allegations associated with the process of hazardous waste incineration. The five Greenpeace case studies, which have received a great deal of public attention and scientific review, have not been shown to be scientifically accurate or factually based. This paper attempts to separate the fact from the fiction, and show some of the consistent inaccuracies which were repeated throughout the five studies most frequently cited by Greenpeace and other activist literature. It also discusses the limited and as yet inconclusive information available from several ongoing studies of smaller facilities in North and South Carolina, as well as some strong conclusions reported from facilities in Germany and Texas.

Despite the widespread prevalence of incineration facilities around the world and the millions of tons of waste destroyed, there are surprisingly few reports of adverse health effects in the

scientific literature relative to other types of waste management practices. The existing reports do not indicate that hazardous waste incineration has widespread potential for adverse health effects, particularly at well-operated facilities.

In fact, high-temperature incineration is uniquely able to prevent future exposure to hazardous chemicals by permanently destroying several million tons of waste each year, and thus poses far lower risks than most other waste management options. As such, the premise of the U.S. EPA's current Combustion Strategy, i.e., that combustion facilities are a major overlooked source of public health risk requiring more stringent controls, appears to be overstated. Increasing public health and environmental protection from mismanaged waste would likely be more readily achieved by enforcing current standards, and by a better understanding of the risks of alternatives to combustion so that preference can be given to alternatives posing lesser risks according to the type of waste to be managed, including combustion where appropriate.

However, as with all industrial processes, care must be taken to ensure waste management facilities are well designed and well operated in order to prevent or minimize the potential for adverse health effects. Poorly operated facilities clearly have the potential to cause adverse effects, particularly in workers, although documented evidence of actual impacts is scarce and still being developed. Ensuring compliance with existing regulations and permits, particularly with regard to occupational exposure, is an important means of meeting goals of health and environmental protection and preventing the potential for adverse effects.

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Note: This paper is an updated version of earlier published editions. Further updates will be published as additional information becomes available.