



Project Summary

Evaluation of the Health Risks Associated with the Treatment and Disposal of Municipal Wastewater and Sludge

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Since 1975 a major research program has been underway at the University of Cincinnati to determine some of the potential human health risks associated with the collection, treatment and land disposal of municipal wastes. The first phase of this effort focused on occupational exposure to viruses and bacteria associated with sewer maintenance and conventional activated sludge wastewater treatment. The second phase of this effort, starting in 1977, included study of exposure to different agents: organic chemicals, fungi and endotoxins; and different processes: composting of wastewater plant sludges, hazardous waste disposal, the spray irrigation of wastewater, and the land application of sludge. The various projects carried out during the second phase of the program are described in this report.

A study of workers involved in composting of wastewater treatment plant sludge by the aerated pile method was initiated to evaluate the potential health effects of exposure to *Aspergillus fumigatus* and other viable and nonviable components of sludge in Camden, N.J., Washington, D.C. and Beltsville, MD. The study consisted of clinical and serologic evaluation of

workers four times a year, physical examinations, and environmental monitoring.

A health study was conducted of the residents of a small community in Hardeman County, Tennessee, who were exposed to carbon tetrachloride and other toxic chemicals in their drinking water as a result of contamination of their domestic wells by a nearby hazardous waste dump. The study consisted of analysis of blood specimens for liver and kidney function parameters, determination of serum and urine bile acid concentrations, physical examinations, interviews and air and water monitoring.

Workers exposed to chlorinated insecticide substances discharged to the sewer by a pesticide formulator were studied at the North Wastewater Treatment Plant, Memphis, Tennessee. The study was undertaken to determine if evidence of exposure to hexachlorocyclopentadiene (HEX), hexachlorobicycloheptadiene (HEX-BCH), heptachlorobicycloheptene, and chlordane could be detected by analysis of urine specimens from the workers.

In order to assess the potential for health risks associated with the spray irrigation of wastewater, a clinical and virus serologic evaluation of workers

and wastewater and air monitoring for viruses, pathogenic bacteria, and volatile organic chemicals was conducted in Muskegon County, Michigan.

A field ecosystem study was carried out at Miami University, Oxford, OH, to evaluate the effects of land application of heat dried municipal wastewater treatment plant sludge (Milorganite) on vegetation, insects and meadow voles.

Reports have been prepared from an evaluation of pertinent literature on potential health effects from viable and nonviable emissions (EPA-600/1-81-006) and persistent organics (EPA-600/1-80-025) associated with wastewater treatment plants and land application sites. The potential health effects associated with sludge incineration and pyrolysis are presented in this report.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back.)

Introduction

Contact with wastewater, wastewater sludge, and waters receiving such discharges have long been regarded as a public health risk. Assumptions concerning these risks have served as a basis for the promulgation of standards for recreational water quality and for the construction and operation of facilities for wastewater and wastewater sludge treatment. However, there is a paucity of documented evidence concerning the nature and extent of the risks involved. The increased pace of construction of new wastewater and sludge treatment facilities in recent years, the improvement of existing facilities and the emphasis on the land application of the residuals produced, lend impetus to the need to evaluate the risks involved. One approach is to investigate the health conditions of individuals engaged in wastewater and wastewater sludge treatment and disposal activities. Among the other approaches are the examinations of populations exposed through contamination of drinking water supplies and the investigation of the effects of sludge applications on the vegetation, insects and mammals in semi-enclosed grassland ecosystems. Each of these approaches was utilized in one or more

of the investigations included in this project.

Sewage Sludge Compost Worker Study

Sewage sludge composting by the windrow method has been practiced for a number of years by the Los Angeles County Sanitation District. More recently the development of the aerated pile composting method by the U.S. Department of Agriculture, Agricultural Research Station at Beltsville, MD, has resulted in considerable expansion of the use of sludge composting. Currently, Philadelphia, PA, Camden, N.J., Washington, D.C., Windsor, Ontario, Bangor and Portland, ME, as well as other cities are engaged in municipal sludge composting. Many other cities are actively considering this method. A number of factors are apparently responsible for the expansion in the use of sludge composting. Among them are the prohibition of ocean dumping of sludge after 1981, the increase in the amount of sludge being produced nationally and the growing emphasis on the land application of wastewater and wastewater sludges. Composting is a thermophilic process and the heat generated helps inactivate the microorganisms present in sludge. However, the heat generated during composting also encourages proliferation of thermophilic fungi, in particular, *Aspergillus fumigatus*, and actinomycetes. *Aspergillus fumigatus*, an opportunistic pathogen, is one of the most prevalent fungi during the sludge composting process. Because they are heat resistant, bacterial endotoxins are also present in composted sludge. A prospective health study was initiated in 1979 to determine if workers at municipal sludge composting facilities are subjected to an increased health risk from exposure to viable fungal particles, actinomycetes, and endotoxins in addition to the pathogenic microorganisms that are normally present in municipal wastewater and sludge. The clinical and serologic evaluation of workers exposed to dust at the composting site included: 1) comprehensive history and physical examination; 2) health questionnaires; 3) illness monitoring; 4) liver and kidney function profiles; 5) anterior nares and oropharyngeal swab cultures; 6) chest X-ray; 7) complete blood count with differential; 8) determination of antibodies directed against *A. fumigatus*; 9) determination of antibodies directed against lipopolysaccharide (LPS) present

in compost samples; 10) skin testing with *A. fumigatus* antigen; 11) pulmonary function tests; 12) quantitation of total IgG, IgM, IgA, and IgE; and 13) determination of C-reactive protein, levels of C3 and CH₅₀. Health questionnaires, anterior nares and oropharyngeal swab cultures and sera for each of the serologic tests were obtained five times during 1979, the first year of the investigation. Statistical comparisons among the groups were made by means of the chi-square, Fisher's Exact and Mann-Whitney one-tailed ranking tests. Environmental monitoring for fungi and bacteria using six-stage Andersen sampler was also conducted several times during the first year.

Pesticide Waste Dump Health Study

Improper disposal of hazardous chemical waste is increasingly being recognized as a source of a potential human health hazard. A health study of the residents of a small community in Hardeman County, TN, exposed to toxic chemicals in drinking water as a result of contamination of their domestic wells was initiated in 1978. The residents were exposed to carbon tetrachloride (CCl₄) and other chlorinated organic contaminants from their private water supply wells and possibly in ambient air. The source of these contaminants in groundwater was probably from leachates from a chemical waste landfill formerly used by a Memphis, TN, pesticide formulator which manufactured chlorinated insecticides. A study to determine if the residents showed any detectable health effects from exposure to toxic organic chemicals in their drinking water was conducted during the Fall and Winter of 1978-1979. The protocol included the analysis of blood specimens for several parameters of liver and kidney function; determination of concentrations of the bile acids, sulfated conjugates of lithocholate (SLCC), and cholyglycine (CG) in urine and serum samples; physical examinations; health questionnaires and air and water monitoring. The data were checked for normality and transformed where necessary. Statistical comparisons among the groups were made using analysis of covariance and with contingency tables. Air samples were collected on Chromosorb 102. Analyses of air, water and urine samples for organic chemicals were performed by electron capture gas chromatography

Exposure to Pesticide Chemicals at a Wastewater Treatment Plant

During a prospective seroepidemiological study of the bacterial and viral disease risks associated with municipal wastewater treatment, an opportunity developed to investigate exposure to toxic organic chemicals emitted from the wastewater during the treatment process at one of the plants in the study. Workers at this plant, the Memphis North Wastewater Treatment Plant, had been complaining in early 1978 of acute symptoms of respiratory distress that they associated with periods of intense chemical odor at the plant. Other symptoms noted were dizziness, headache, and irritation of the eyes, nose, throat, lungs and skin. The treatment plant is located near a manufacturer that produces and utilizes several chlorinated organic intermediates for the formulation of flame retardants and chlorinated insecticides (notably isodrin, endrin, chlordane and heptachlor). Chemical waste from this manufacturer is discharged into a sewer that flows to the Memphis North Wastewater Treatment Plant. During 1978 exposure to several chlorinated organic compounds including HEX and HEX- BCH at this treatment plant was assessed by evaluating urinary excretion, illness symptoms and air and wastewater contamination. Chemical analyses were performed by electron capture gas chromatography. The data were checked for normality and transformed where necessary. Statistical comparisons among the groups were made using analysis of covariance.

Exposure of Wastewater Spray Irrigation System Workers to Viruses, Bacteria and Organic Chemicals

As a result of legislative actions, such as the 1972 Clean Water Act and its 1977 Amendments, land application of municipal wastewater and sludge after pretreatment is becoming increasingly popular as an alternative means to the more conventionally used disposal methods, such as ocean and surface water dumping, and incineration. Spray or sprinkler application is one of the commonly used methods of land application of wastewater. The volatile organic chemicals and microorganisms present in wastewater may become airborne during spray application and are a potential risk to the workers

involved with the operation of the facility. In order to assess the potential health risks of workers from exposure to volatile organic chemicals and viruses in aerosols, the ambient air environment and the workers at the Muskegon County Wastewater Management System, MI, were evaluated. Air samples for animal virus and coliphage assay were collected with an Army prototype XM2 Biological Sampler/Collector. Air sample filtrates were inoculated into BGM cells derived from primary African green monkey kidney cells. Coliphage assay of air and water samples was by the soft agar overlay method. Six-stage viable particle Andersen samplers were used for the collection of air samples for the determination of total bacteria, total and fecal coliforms and for the identification of gram-negative and gram-positive bacteria. The concentration of chloroform, carbon tetrachloride, trichloroethane, trichloroethylene and tetrachloroethylene in air samples collected on Chromosorb 102 and charcoal tubes and in water samples were determined by use of electron capture gas chromatography. Blood samples, throat and rectal swabs and illness symptom data were collected on a monthly basis from June through October. Antibodies to poliovirus types 1, 2 and 3, coxsackievirus types B2 and B5 and echovirus types 7 and 11 were determined using a microneutralization technique. Comparisons between the groups for the virus serology results were accomplished by contingency tables and chi-square analyses. Viral cultures from throat and rectal swabs were inoculated into cell cultures of African green monkey kidney, vero monkey kidney and WI-38. Viruses, including those recovered from wastewater, were identified by neutralization with Lim-Benyesh-Melnick antisera pools.

Effects of Wastewater Treatment Plant Sludge on Two Grassland Ecosystems

A field ecosystem study was carried out at Miami University, Oxford, OH, to evaluate the effects over a two-year period of land application of heat dried municipal sludge (Milorganite) on vegetation, insects and meadow voles in sixteen one quarter acre semi-enclosed plots. Eight of the plots were initially in the fourth year of grassland succession (perennial field) and eight had previously

been sowed to winter wheat (annual field). Six of the plots received surface application of Milorganite monthly for five months during the growing season, six received a commercial fertilizer containing equivalent amounts of nitrogen-phosphorus and potassium and four were controls. Five breeding pairs of the meadow vole *Microtus pennsylvanicus* were placed inside each enclosure in the Spring of each year.

The study focused on three aspects of the grassland ecosystems which may be affected by sludge deposition: structure and energetics of the total ecosystems, population dynamics of small mammals, and population dynamics of arthropods. Comparison between control and experimental plots in each grassland type provided information regarding the effects of sludge on the ecosystem as a whole. Comparison of the experimental plots between the two grassland types provided information as to which ecosystem is better able to process sludge most efficiently. The effects of sludge on vegetative community structure was considered by comparison of species diversity between control and experimental plots. Productivity was measured by the short-term harvest method. Diversity was determined by the number of species per 0.25 m², Margalef's richness index, Shannon-Weaver's function, and Pielou's evenness index. Vole population dynamics in the control and experimental systems were compared on the basis of age structure, turn-over rate, population growth rate, and carrying capacity. Vole population densities were related to vegetation nutrient content in a test of Pitelka and Shultz theories of nutrient-recovery and nutrient cycling effects. Arthropod response to treatment was evaluated for all major orders in terms of density and biomass. One order (Homoptera) was analyzed in detail regarding species richness and apportionment. During November of each year the voles were sacrificed for a complete autopsy and for histopathology of liver, lungs, kidney and testes or ovaries. These organs were also analyzed for cadmium, lead, copper and zinc content.

Potential Health Effects From Viable and Nonviable Emissions Associated With Sludge Incineration and Pyrolysis

A literature review of chemical, biological, and environmental literature

was initiated in 1978 to evaluate the potential health effects of emissions from wastewater and sludge treatment operations including land application from agents such as viruses, pathogenic microorganisms, toxins and persistent organics. Individual reports have been prepared from the literature evaluation on viable and nonviable emissions (EPA-600/1-81-006) and persistent organics (EPA-600/1-80-025). Potential health effects of incineration and pyrolysis of sludge are discussed in this report.

Conclusions

Some of the conclusions of the various investigations involved in this project are as follows.

Sewage Sludge Compost Workers Study

1. Results of the environmental monitoring demonstrated that workers at each of the compost sites were exposed to markedly elevated numbers of *A. fumigatus* spores. This observation was further supported by the comparatively high frequency of isolation of *A. fumigatus* from oropharyngeal and anterior nares cultures of compost workers when compared to the intermediate-exposed and control groups.
2. Preliminary analyses of the highest results obtained for each participant on tests for the enzymes serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), measures of liver function; absolute eosinophil count; total IgG, IgE, and IgM antibodies; and specific IgG antibody directed towards *A. fumigatus*, determined by the enzyme-linked immunosorbent assay, did not reveal any differences among exposure groups at any of the sites.
3. The only significant difference in an examination of C-reactive protein (CRP) was found among Beltsville workers. Four of nine compost workers had positive CRP values compared to none of eight intermediate-exposed workers.
4. Levels of antibody directed against lipopolysaccharide (LPS) prepared from site-specific compost as determined by the enzyme-linked immunosorbent assay were not

found to be higher among Camden compost workers than in control workers. However, in Beltsville and Blue Plains antibody titers among compost workers were higher than in their corresponding lower exposure groups.

5. One worker in the study, employed at a compost site, was found to have a local infection involving his right ear. This infection caused by *A. niger* gradually progressed over a period of several months. Despite treatment, there was erosion of 70% of the right tympanic membrane.
6. Chest X-rays were obtained from 74 participants and reviewed by a radiologist at the University of Cincinnati. Of these, one compost worker's X-ray exhibited an abnormality compatible with an occupationally-related disorder.

Pesticide Waste Dump Health Study

7. Concentrations of CCl_4 in the contaminated wells were of the order of $5000 \mu\text{g/L}$. Assuming a consumption of one liter per day, the individuals using the contaminated water had a dose of about 5 mg/day , CCl_4 .
8. Results from the initial screening in November 1978 after almost all potable use of the contaminated water had ceased, revealed that the concentrations of the serum enzymes alkaline phosphatase, SGPT and SGOT were elevated in the group of residents who had previously consumed the contaminated water when compared to the control group. The differences appear to be associated with the ingestion of well water contaminated by leachate from a toxic waste landfill. Two months later many of the persons with abnormal test results had results in the normal range.
9. During the January 1979 survey, six individuals from the exposed group and one from the intermediate-exposed were found to have enlarged livers.
10. The mean nonfasting serum bile acid, sulfated conjugates of SLCC, was significantly lower in the exposed group than in the control.

11. For those persons in the exposed group who were tested in both November 1978 and January 1979 nonfasting serum concentrations of SLCC and CG were significantly higher in November 1978 than in January 1979.
12. The potential long-term health effects of exposure to these chemicals in drinking water is not known.

Exposure to Pesticide Chemicals at a Wastewater Treatment Plant

13. Influent wastewater from the North Plant, and air samples collected at the wet well and grit chamber of the North Plant in Memphis, TN, contained several contaminants including HEX, HEX-BCH, heptachlorobicycloheptene and chlordane.
14. Influent wastewater and air samples obtained at the grit chamber of the Maxson Plant, the control plant in Memphis, TN, did not contain the type of substances found in the samples obtained at the North Plant.
15. Urinary excretion of HEX-BCH was found to increase during the work shift for workers at the North (exposed) plant in the June 1978 survey, whereas it decreased during the work shift at the Maxson (control) plant. The percent of exposed plant urine samples with HEX-BCH concentrations greater than $3 \mu\text{g/L}$ increased from 7 to 41 during the work shift while in control plant samples the percent decreased from 9 to 0, during the June 1978 screening.
16. The significance of the presence of these chlorinated organic chemicals in the urine of workers and the potential long-term health effects of exposure to these chemicals is not known.

Exposure to Wastewater Spray Irrigation System Workers to Viruses, Bacteria and Organic Chemicals

17. No animal viruses were detected in air samples collected at the Muskegon County Wastewater Management System using the Army prototype XM2 Biological Sampler/Collector.

18. Animal viruses were detected in raw influent samples but decreased in concentrations as the wastewater was aerated and stored in the lagoons. None were detected in wastewater at the pump station just prior to distribution to the spray irrigation rigs.
 19. Using the centrifugation-filtration method all raw influent samples were found to contain viruses, ranging from 50 to 400 plaque-forming units/liter.
 20. Coliphage were removed from air samples at the aeration basins in concentrations ranging from 0-9 per cubic meter of air. *E. coli* 13706 coliphage was recovered more often than the other two tested, 15597 and 11303.
 21. Illness and virus isolation rates were not significantly different in the study group of workers engaged in the spray irrigation of wastewater compared to a control group of road commission workers.
 22. Antibody titers to coxsackievirus B5 were significantly higher for one subgroup of wastewater workers, the spray irrigation nozzle cleaners, when compared to either other wastewater workers or to the road commission workers. This suggests that there may be a risk of viral infection only in those with the greatest and most direct exposure to wastewater.
 23. The prevalence of Hepatitis A antibody correlated with age, as would be expected in normal populations, and there was no increase in the prevalence of Hepatitis A antibody in those exposed to spray irrigation.
 24. Antibody titers to poliovirus 1, 2 and 3, coxsackievirus B2 and echovirus 7 and 11 were not different between the wastewater and road commission worker groups.
 25. The quantity of bacteria in the air downwind of treatment sources at the Muskegon wastewater site contained higher total numbers of bacteria and higher percentages of gram-negative bacilli, fecal-indicator bacteria, and pathogenic bacteria than upwind air.
 26. The mean respirable concentration of the total airborne bacteria found one meter downwind of the aeration basin at the Muskegon wastewater site was 2800 Colony Forming Units (CFU) per m³ which was significantly higher than that found 18 meters downwind of the spray irrigation rigs (i.e., 700 CFU per m³). Concentrations one meter upwind of the aeration basin and 18 meters upwind of the field rigs were 490 CFU/m³ and 660 CFU/m³, respectively.
 27. Relatively high airborne levels of respirable *Klebsiella* spp. were found downwind of wastewater operation compared to most other recent studies.
 28. Concentrations of trichloroethane, trichloroethylene and tetrachloroethylene at the Muskegon County Spray Irrigation System at the downwind edge of the aeration basins ranged up to 90 µg/L, 73 µg/L and 46 µg/L, respectively. Adjacent to the spray irrigation rigs the highest concentrations reached for the same compounds were 2.7, 9.3 and 8.6, respectively. All of these concentrations were well below the 8-hour occupational standards of 45,000 µg/L, 535,000 µg/L and 670,000 µg/L, respectively.
 29. Chloroform was not detected in the air adjacent to the spray irrigation rigs but was detected downwind of the aeration basins at concentrations ranging up to 202 µg/m³ (8-hour occupational limit 50,000 µg/m³). In the scrubber house chloroform was detected at 3380 µg/m³.
 30. Comparing upwind and downwind air concentrations with influent and effluent wastewater concentrations at the aeration basins showed that significant concentrations of the volatile substances measured are stripped from the wastewater during the aeration process.
- Effects of Wastewater Treatment Plant Sludge on Two Grassland Ecosystems**
31. When heat-dried Milwaukee, Wisconsin wastewater treatment plant sludge (Milorganite) and a commercial fertilizer were applied so that the amounts of added nitrogen and phosphorous were equivalent, the ratio of the amount of the following heavy metals in Milorganite to that in fertilizer was 495 for lead, 167 for cadmium, 953 for copper and 280 for zinc in 1978. In 1979 the ratios were 209, 205, 1163 and 334, respectively.
 32. The Shannon-Weaver diversity index was lower in the wheat fields receiving Milorganite than in the wheat fields receiving commercial fertilizer and the controls. No significant differences were observed in this index in the old grass fields suggesting that the perennial (old) community is more stable than the annual (wheat) field and better suited for application of sludge than the annual field.
 33. For arthropods, the fertilizer and sludge plots exhibited consistently higher species richness values than did the control plots in both types of fields. The opposite was true with respect to apportionment values.
 34. Survivorship, longevity, percentage of breeding adults and recruitment rates of the meadow voles were not affected by sludge treatment.
 35. No pathologic alterations were seen in the lungs and kidneys of the meadow voles from the fertilized, sludge-treated and control plots of both the perennial or annual fields.
 36. For both the annual and perennial fields the incidence of liver degeneration in the meadow voles did not differ between the fertilized and sludge treated plots but was lower in the control plots.
 37. Meadow voles from the sludge-treated annual field showed a more severe liver degeneration than those from the sludge-treated perennial fields.
 38. There were no differences in tissue concentration of Pb, Zn and Cu of meadow voles from any of the fields. However, Cd concentrations were elevated in kidneys and livers of all sludge-treated voles for both the annual and perennial fields.

Potential Health Effects From Viable and Nonviable Emissions Associated With Sludge Incineration and Pyrolysis

39. A literature evaluation indicated that incineration and pyrolysis processes may lead to air pollution from volatilization of heavy metals and incomplete combustion of organic chemicals, respectively. The air pollution can be controlled by the use of appropriate control measures in both incineration and pyrolysis processes and also by afterburning in the case of pyrolysis.

Recommendations

1. Compost workers should be observed over an extended period of time to reveal abnormalities which may be related to the length of exposure.
2. The preliminary data on antibody response of the compost workers to lipopolysaccharide prepared from compost samples suggests that it may be advisable to take precautions to reduce exposure, such as the use of respirators by compost workers and periodic water spraying of the compost sites to reduce dust.
3. A method should be developed to quantify the presence of endotoxin in compost and in the air.
4. Long-term medical follow-up of the residents of Toone-Teague Road, Hardeman County, TN, should be initiated.
5. Necessary precautions should be taken, if possible, to prevent the contamination by these toxic chlorinated organic chemicals of the artesian aquifer below the Hardeman County dump site, since it is used as a water supply for the City of Memphis.
6. The closure plan for this dump site should be designed to prevent an increased exposure to nearby residents and to those downstream and downwind to contaminants associated with the dump.
7. Industrial discharge of toxic chemical waste into municipal sewerage systems should be controlled and monitored.
8. A follow-up study of the workers involved at the Memphis North Treatment Plant should be conducted to determine if urinary excretion of HEX and HEX-BCH remains at the low levels detected in September 1978 and if any health effects are apparent.
9. The XM2 Biological Sampler/Collector should be used for a sampling period of at least several days to determine if animal viruses can be detected in aerosols sampled by this method at the Muskegon, MI spray irrigation site.
10. The virus content of solid material at the bottom of the lagoons and aeration basins at the Muskegon, MI spray irrigation site should be determined to see if future disposal of the solid material would be a problem.
11. The Kott's MPN method is recommended for use when coliphage levels are expected to be very low.
12. Because of problems with the XM2 sampler and sterilization and arcing problems in other large volume samplers, an improved large volume biological air sampler should be developed.
13. Resistant aerosolized bacteria such as *Klebsiella* should be explored as possible indicators of bacterial air contamination from fecal sources.
14. An examination of the serum of workers at the Muskegon spray irrigation site for antibodies to *Klebsiella* should be initiated.
15. Routine air monitoring for selected organic compounds should be performed downwind of the aeration basins and in the scrubber house at the Muskegon spray irrigation site.
16. The observation of an apparent increased risk in nozzle cleaners at Muskegon should be confirmed. The number of available nozzle cleaners is small, but a serologic survey of former nozzle cleaners could be conducted.
17. The hypothesis that wastewater workers may be at risk of Legionnaire's disease could be evaluated further by testing for antibody to *Legionella pneumophila* which has been related to blue green algae. Wastewater irrigation workers may be exposed to wastewater with higher algae content than ordinary wastewater treatment plant workers.
18. For minimizing effects on small mammal populations mid-successional old-fields should be used as sites for the land application of sludge, rather than early successional stages or agricultural fields.
19. Research should continue to more completely characterize the effect of sewage sludge application on mammal populations, especially to evaluate if Cd concentrations tend to increase in the kidneys and livers of animals functioning within sludge-treated plant communities.
20. Afterburning should be used in the pyrolysis process to assure complete combustion of organic chemicals in sludge.

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Herbert R. Pahren is the EPA Project Officer (see below).

The complete report, entitled "Evaluation of the Health Risks Associated with the Treatment and Disposal of Municipal Wastewater and Sludge," (Order No. PB 81-175 945; Cost: \$20.00, subject to change) will be available only from.

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