



Project Summary

Evaluation of Health Risks Associated with Wastewater Treatment and Sludge Composting

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The risks to human health from exposures to biological and chemical agents in waste materials are a primary motivating factor for improving the practices for storing, transporting, treating and ultimately disposing these wastes. Four areas of research of potential health effects related to waste exposures from wastewater treatment plant sludge composting, municipal wastewater treatment, and toxic waste dump leachate, were undertaken under this Cooperative Agreement. The specific areas were: (1) a prospective health study of workers engaged in the composting of wastewater treatment plant sludge, (2) serologic analyses of inexperienced and experienced wastewater-exposed workers, (3) a mortality study of former employees of a large wastewater treatment system, and (4) selected chemical analyses of biological specimens from a population whose drinking water had been contaminated with leachate from a pesticide waste dump. Each of these studies had its origins in previous research efforts, the results of which have been reported elsewhere.

The study involved compost workers at compost sites in Camden, NJ, Philadelphia, PA, Beltsville, MD, and Washington, DC, and control groups. Physical examinations of the workers showed an excess of abnormal skin, nose, and ear conditions. In addition, several of the laboratory tests were suggestive of low-grade inflammatory response. Viable units of the fungus *Aspergillus fumigatus* were frequently

detected in cultures of throat and nasal swabs of compost workers and were rarely detected in workers with little or no compost exposure. The effects observed in the compost worker study may be due to the nature of the compost process itself and therefore may not be related specifically to the use of wastewater sludge in the composting operations. However, they do justify a continuation of health studies of workers engaged in the composting of waste materials. The fact that sludge composting has been practiced for a relatively short period of time adds to the need for additional study.

Using a serum bank established in an earlier study of wastewater workers and controls in Cincinnati, OH, Chicago, IL, and Memphis, TN, the present study evaluated possible viral factors that may be included in the previously detected excess in gastrointestinal illness observed among workers during their first two years of wastewater employment. Testing for antibody to Hepatitis A (anti-HAV) virus was among the other tests performed. Analysis of paired sera from workers who reported gastrointestinal illness indicated that among inexperienced workers, Norwalk agent was associated temporally with 13% of these illnesses. Inexperienced wastewater-exposed workers had higher levels of antibody to Norwalk agent than did experienced and control workers ($p = 0.03$). The presence of anti-HAV was not different among the inexperienced wastewater workers,

experienced wastewater workers, and controls, and was not associated with length of wastewater exposure for the exposed wastewater workers. However, anti-HAV was found to be associated with race ($p \leq 0.0001$) and age ($p < 0.001$).

An analysis of 815 death certificates from former workers at the Metropolitan Sanitary District of Greater Chicago revealed that for a relatively rare cause of death, leukemia (1 in 134), the proportion of workers with this cause of death was about twice as many as expected (11 observed, 6 expected; $p = .04$). For another relatively rare cause of death, cancer of the esophagus (1 in 215) there was also about twice as many observed as expected deaths which was almost significant using U.S. Vital Statistics ($p = 0.08$) but not using Illinois Vital Statistics ($p = 0.13$). A more common cause of death, pneumonia (1 in 41), less than one-half as many deaths as expected were observed ($p = 0.02$). Recommendations for further study are made.

A previous study of a population whose drinking water had been heavily contaminated with leachate from a pesticide waste dump had revealed higher levels of several liver function tests and enlarged livers among the exposed population. In the present study, specimens available from the earlier study were examined to determine if specific contaminants could be detected in the serum or if an overall indication of chemical exposure, urinary thioether concentrations, was elevated. Analysis for volatile organic chemicals in serum from individuals whose drinking water had previously been contaminated did not reveal higher levels when compared with results from specimens from non-exposed individuals. Concentrations of thioethers in urine specimens were not found to be significantly higher in specimens from workers at a wastewater treatment plant receiving wastes from a pesticide manufacturer, than in those from a control plant and were also not significantly higher in individuals previously exposed to chemically-contaminated drinking water than in controls.

This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, 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

The risks to human health from exposures to biological and chemical agents in waste materials are a primary motivating factor for the improvement in practices for storing, transporting, treating, and ultimately disposing of these wastes. Four areas of research of potential health effects related to waste exposures from wastewater treatment plant sludge composting, municipal wastewater treatment, and toxic waste dump leachate were undertaken under this Cooperative Agreement. The specific areas were: (1) a prospective health study of workers engaged in the composting of wastewater treatment plant sludge, (2) serologic analyses of inexperienced and experienced wastewater-exposed workers, (3) a mortality study of former employees of a large wastewater treatment system, and (4) selected chemical analyses of biological specimens from a population whose drinking water had been contaminated with leachate from a pesticide waste dump. Each of these studies had its origins in previous research undertakings, the results of which have been reported elsewhere. The compost workers study and the mortality studies were a continuation and an expansion, respectively, of earlier studies. The other two projects made use of serum and urine available from previously-completed studies.

The ultimate disposition of the residuals resulting from the treatment of municipal wastewaters, i.e., sludges, has been a major problem facing many municipalities. Legislation which prohibited ocean dumping of sludge after 1981 has forced many municipalities to develop alternative disposal methods. One option which has been considered is the application of wastewater and sludge to the land for crop irrigation or as an organic soil amendment. The composting of sewage sludge has been shown to yield a product which appears to be biologically safe and well suited for ultimate land disposal. The composting of wastewater treatment plant sludge has increased considerably in the past several years in the U.S. and elsewhere. As recently as ten years ago sludge composting in the U.S. was practiced mainly by Los Angeles County, using the windrow method. The development of the aerated pile method by the U.S. Department of Agriculture at Beltsville, MD, prohibitions against ocean dumping, and the increased cost of alternative sludge treatment methods have led to a rapid expansion in systems

for composting sludge prior to its land application.

Successful year-round outdoor composting sites are operating in many areas of the Northeast and Midwest. Currently Philadelphia, PA, Camden, NJ, Washington, DC, Columbus, OH, Windsor, Ontario, Bangor and Portland, ME, as well as other smaller cities, have initiated composting of municipal sludge by the aerated pile method. Although the numbers of pathogenic bacteria and viruses are effectively reduced by the high temperatures achieved in composting, conditions are ideal for the growth of thermophilic microorganisms, such as the fungus *Aspergillus fumigatus*. Therefore, workers directly associated with the composting process will be exposed to high concentrations of microorganisms; not only those microorganisms present in the raw sludge, but also those which proliferate during the composting process such as *Aspergillus fumigatus*. The dust at composting sites has also been shown to contain significant quantities of lipo polysaccharide (LPS) derived from viable and non-viable gram-negative microorganisms which are present in sludge. Workers at composting sites are exposed to potential human pathogens, bacterial endotoxins, and other microbial toxins via inhalation of dust generated by manipulation of the compost piles and by inadvertent ingestion of compost or sludge through dirtying of the hands or face with compost or sludge and subsequent transport to the mouth. The compost worker study included in the Cooperative Agreement has focussed on an evaluation of the health effects of chronic, long-term exposure of workers at composting facilities to the combination of microbial pathogens, microbial toxins, and LPS present in the work environment at composting sites.

The potential health effects of exposure to municipal wastewater treatment processes are not only important to the workers at these plants and ultimately to designers of these plants and other involved in their construction, financing and regulations, but also to communities that are neighbors to existing and future plants. An infectious disease study of a municipal wastewater treatment plant in Cincinnati, OH, Chicago, IL, and Memphis, TN, concluded that although no evidence was found to support the existence of any significant health effects from occupational exposure to viruses in wastewater, an excess of reports of gastrointestinal illnesses was detected among the inexperienced wastewater

exposed workers. Also, several recommendations for additional studies were made to aid in the interpretation of the results. These recommendations have been carried out under this Cooperative Agreement.

Another approach to determine health effects of occupational exposure to wastewater treatment operations is a study of the causes of death of former employees in wastewater treatment systems. An interim report on such a study was presented by the authors at a 1979 EPA symposium. The interim report of former employees of the Metropolitan Sanitary District of Greater Chicago did not indicate any excesses of any of the major causes of death. This mortality study was expanded under the present Cooperative Agreement to include twice as many decedents and to include more detail on causes of death and to examine the relationship between cause of death and various aspects of employment history.

Human health risks from improper disposal of toxic wastes has become an increasingly important issue in recent years. A study of the health effects on a rural community in western Tennessee from leachate from a pesticide waste dump was conducted under a previous U.S. EPA grant. In the Hardeman County study we detected abnormalities in certain liver function tests and in excess of people with enlarged livers in the exposed population when compared to controls. Exposure was well-documented by means of water analyses by various public agencies and by limited air sampling that we had conducted. However, only limited biological monitoring was included in the previous study and the emphasis was on compounds we were investigating elsewhere and not on the more abundant compounds in the contaminated well water. Under the present Cooperative Agreement, additional biological monitoring was undertaken on the Hardeman County population and on a wastewater worker population exposed to the same wastes. Some of this research was performed under a U.S. EPA Cooperative Agreement at the University of Miami, Florida.

Conclusions

1. Physical examinations of the workers participating in this study revealed an increased incidence of the following abnormal findings in compost and intermediate-exposed workers: acute and/or chronic inflammation or infection of the skin,

evidence of acute and/or chronic inflammation of the nasal mucosa and eyes, and evidence of acute and chronic infections of the ear. The high prevalence of these findings in compost and intermediate-exposed workers and not in the controls suggests that they may be related to compost exposure.

2. The presence of an occupational pulmonary disease was detected on the chest X-ray in one worker with four years exposure to composting. Due to the small number of workers with >3 years work exposure in the study, this may be very significant.
3. Compost workers had no evidence of abnormalities of liver or renal function during the study period.
4. Hemolytic complement (CH₅₀) titers and white blood cell counts were elevated in compost workers as compared to controls; the elevations were not observed during all sampling periods and may have been related to seasonal variations in exposure conditions at the compost sites. Concentrations of C3 and C-reactive protein were similar among all exposure groups.
5. There was no correlation of serum concentrations of the immunoglobulins G, M, A, and E by worker exposure group.
6. Compost workers appear to have higher levels of IgG antibody against compost-derived lipopolysaccharide.
7. Compost exposure does not seem to have a consistent effect on levels of IgG antibody against *A. fumigatus*.
8. Extremely high numbers of *A. fumigatus* and other thermophilic fungi were detected in the environment at the compost sites studied; both total and respirable numbers were significantly above expected background levels. Highest concentration of fungi were detected downwind from active compost sites.
9. Cultures of the throat and anterior nares of workers at compost sites were frequently positive for *Aspergillus fumigatus*; similar cultures obtained from workers in the intermediate-exposed and control groups (exposure groups II and III) were almost always negative for *A. fumigatus*. These results demonstrate that exposure of workers to high

concentrations of fungal spores in the work environment results in viable colony forming units of the fungi being routinely present in the upper respiratory tract.

10. All workers screened lacked precipitating antibodies to the following antigens: H and M antigens of *Histoplasma capsulatum*; and a pool of antigens prepared from *A. fumigatus*, *A. flavus*, *A. carneus*, and *A. niger*. These results suggest that infection caused by these fungi were uncommon among the workers studied, despite exposure of workers at compost facilities to extremely high numbers of fungal spores.
11. Seroconversions to *Legionella pneumophila* were more common in study participants in the Camden-Philadelphia area than in the Washington, DC metropolitan area. However, there was no evidence of increased risk of infection in compost-exposed workers caused by this organism suggesting that exposure to *Legionella* species is not a risk of sludge compost employment.
12. There appears to be a pattern of increased numbers of symptoms of skin irritation and burning eyes among compost-exposed workers compared to those non-exposed during the fall and winter seasons.
13. Wastewater-exposed workers in the study do not appear to be at increased risk to infection with hepatitis A. Antibody to hepatitis A was found to be more prevalent in black workers than in white workers and was positively associated with age.
14. In Cincinnati, an apparent infection with Echovirus 3, which had previously been suspected on the basis of isolation of the virus from throat and rectal swabs, was serologically detected in inexperienced sewage-exposed workers. An infection with Echovirus 6, detected by a previous study through rising titer levels from January-October 1977, was apparently preceded by an infection in 1976 as evidenced by higher antibody prevalence but not by statistically higher titer level rises.
15. About 13% of the gastroenteritis reported by inexperienced sewage-exposed workers appears to be associated with Norwalk agent. Infection with Norwalk agent ap-

pears to be a risk of the first two years of exposure to wastewater and it may also be associated with level of biological aerosol exposure.

16. Antibody to the alga prototheca does not appear to be consistently higher among wastewater-exposed workers than control groups.
17. An analysis of 815 death certificates from workers in a wastewater treatment system revealed that for a relatively rare cause of death, leukemia (1 in 134), the proportion of workers with this cause of death was about twice as many as expected (11 observed, 6 expected: $p = .04$). For another relatively rare cause of death, cancer of the esophagus (1 in 215) there was also about twice as many observed as expected deaths which was almost significant using U.S. Vital Statistics ($p = 0.08$) but not using Illinois Vital Statistics ($p = 0.13$). For a more common cause of death, pneumonia (1 in 41), less than one-half as many deaths as expected were observed ($p = 0.02$).
18. Analysis for volatile organic chemicals in serum from individuals whose drinking water had previously been contaminated by a pesticide waste dump did not reveal higher levels when compared with results from specimens from non-exposed individuals.
19. Concentrations of thioethers in urine specimens were not found to be significantly higher in specimens from workers at a wastewater treatment plant receiving wastes from a pesticide manufacturer, than in those from a control plant and were also not significantly higher in individuals previously exposed to chemically-contaminated drinking water than in controls.

Recommendations

1. Physical examinations should be conducted on as many of the original compost study participants as possible and on additional compost workers to determine if the abnormal findings evident in this study regarding skin, nose, ears, and eyes can be confirmed. These examinations should include: cultures of anterior nares and oropharyngeal swabs, complete blood count with differential, serum gamma glutamic transaminase, ELISA-determined

IgG antibody against compost-derived LPS, CH_{50} , and IgE.

2. Investigations should be conducted of the long-term effects of exposure to composting on the pulmonary system; the testing should include pulmonary function testing, chest X-ray, and physical exam.
3. It is important to determine whether individuals with chronic diseases such as diabetes, chronic pulmonary disease, allergic disorders, etc. are at greater risk of developing abnormalities during exposure to composting.

Testing for these individuals:

- pulmonary function testing
- chest X-rays
- physical examinations
- history and illness monitoring

Optional tests

- complete blood counts
- erythrocyte sedimentation rates: index of ongoing inflammatory response
- liver and renal function tests
- determination of antibody to LPS and *A. fumigatus* antigens.

4. In order to gain further insight into the etiology of gastroenteritis among wastewater workers, sera collected before and after such episodes, along with rectal swabs and stool collected during the acute phase of the illness, should be analyzed to determine the agents involved. Norwalk agent and related viruses and toxigenic or invasive *E. coli* should be included in the serologic testing. Swabs and stool should be examined for the presence of bacteria, viruses and parasites.
5. In order to determine if the apparent excess of leukemia deaths persists in a larger population, the Mortality Study of Chicago Metropolitan Sanitary District Workers (MSD) should be expanded by: (1) analysis of 1960-76 decedents not included in the present study, (2) extension of the study to include 1977-1982 decedents, and (3) extension of the study to include all MSD decedents prior to 1960.
6. A mortality study of wastewater workers in another metropolitan area should be initiated to determine if an excess of deaths by

leukemia has occurred in other wastewater worker populations.

7. Since the test for urinary thioethers appears to be potentially useful as a biological indicator of chemical exposure, it should be utilized in studies of other populations exposed to chemical wastes.

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Walter Jakubowski is the EPA Project Officer (see below).

The complete report, entitled "Evaluation of Health Risks Associated with Wastewater Treatment and Sludge Composting," (Order No. PB 85-115 889; Cost: \$23.50, subject to change) will be available only from:

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