



## *Project Summary*

# Health Risks of Human Exposure to Wastewater

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The primary objective of this research was to determine the health effects associated with occupational exposure to biological agents present in municipal wastewater. An additional objective was to determine the sensitivity of the methodology for detecting potential health impacts of other wastewater exposures, such as recreational contact with surface water receiving wastewater effluents. The procedure was a prospective sero-epidemiologic study applied to municipal wastewater workers and controls in three metropolitan areas: Cincinnati, Ohio; Chicago, Illinois; and Memphis, Tennessee. The primary study group consisted of more than 100 workers recruited at the time they began work at activated sludge plants and who remained in the study for a minimum of 12 months. In addition, a Chicago group of 30 experienced sewage treatment plant workers were included and, in Cincinnati, two other wastewater-exposed groups were recruited consisting of about 50 sewer maintenance workers and 50 primary wastewater treatment plant workers. The latter group was recruited into the study just before start-up of plant improvements that included activated sludge facilities. The purpose of including this group was to differentiate between aerosol exposure and exposure to wastewater and sludge through those operations associated

with primary wastewater treatment.

The protocol involved quarterly collection of blood, throat, and rectal swabs; yearly medical examinations; collection of illness information; work observations; and environmental monitoring. Initial recruitment of workers began April 1975 in Cincinnati; July 1976 in Chicago; and July 1977 in Memphis. Final specimens in all cities were collected in the fall of 1978. The serological survey included testing for antibodies to a large group of viruses and bacteria and determination of immunoglobulin levels. Work observations were used to evaluate the level of the workers' contact with wastewater and, in conjunction with the biological air monitoring, to assess the extent of contact with aerosols. The environmental monitoring included viral and bacterial analyses of wastewater and the use of six-stage Andersen samplers to determine the respirable concentrations of bacteria in the work areas of the plant.

A total of over 500 volunteers participated in the study including both subjects and controls.

*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

### Objectives

The purpose of this study was to determine the health effects, if any, of the occupational exposure to the viruses, bacteria, and parasites present in municipal wastewater. The central feature was an extensive surveillance of the health of 100 newly-hired activated sludge treatment plant workers during a minimum of 12 months of occupational exposure to wastewater. Specific objectives of the project were:

1. To determine whether wastewater workers develop clinical illness or specific bacterial, viral, and parasitic infections due to occupational exposure to sewage
2. To determine the immunologic response among workers presumed to be exposed to a high level of antigenic stimulation, i.e., through wastewaters.
3. To determine whether wastewater workers serve as a reservoir of certain infections and, if so, whether members of the workers' families are affected.
4. To determine the effect of exposure to aerosols generated by the activated sludge treatment process.
5. To determine the concentration of bacterial aerosols at wastewater treatment plants, and to compare them to levels at other public works facilities.

An underlying objective of the study was the determination of the sensitivity of various elements of the epidemiological-serological approach for the detection of wastewater-related health effects. Such a determination would permit an assessment of the potential application of this methodology to the study of health risks associated with other population exposures to wastewaters. The latter would include persons working with or living near wastewater land-disposal facilities, persons living in the vicinity of wastewater treatment plants, and persons engaged in recreational use of bodies of water receiving waste effluents.

## Background

Information regarding the human health risks associated with contact with wastewater and related materials brought about by occupational and other exposures is limited. However, assumptions concerning these risks are providing motivation for the promulgation of state and federal standards designed to protect populations from various wastewater

exposures. The growing emphasis on the land application of wastewater and sludges as a viable method of wastes utilization increases the need for reliable and up-to-date information on the health risks, if any, involved. Wastewater also contains a wide variety of harmful chemicals which may under some conditions compromise the health of wastewater workers. However, chemical hazards were not considered in this study.

**Table 1.** *List of Viruses, Bacteria, and Immunoglobulins for Which Workers' Sera Were Tested for Antibodies.*

### Viruses

1. Polio 1, 2, and 3
2. Coxsackie A-7, A-9, A-16, A-21, and B-1 to B-6
3. Echo 1, 3, 4, 5, 6, 8, 9, 11, 13, 14, 19, 24, 30
4. Reovirus
5. Adenovirus
6. Cytomegalovirus
7. Herpes simplex
8. Hepatitis A antibody and Hepatitis B antibody and antigen  
*Test Methods: Microneutralization for Polio, Coxsackie and all Echo viruses; Radioimmunoassay for Hepatitis A and B; and Complement Fixation for the others.*

### Bacteria

1. Salmonella: Group A, B, C, D, and E  
*Test Methods: Rapid slide agglutination (1975-1976)  
Microagglutination (1978)*
2. Leptospira  
*Test Method: Microagglutination*
3. Legionella pneumophila  
*Test Method: Indirect immunofluorescence*

### Immunologic Factors

1. IgA
2. IgG
3. IgM
4. Rheumatoid Factor  
*Test Methods: Radial immunodiffusion for immunoglobulins, latex reaction for rheumatoid factor*

## Methods

The study consisted of an intensive serologic survey correlated with epidemiological, clinical, and environmental data on the study populations. The central feature of the design was an evaluation of the effects of occupational exposure to wastewater over at least a 12-month period based on the measurement of specific viral and bacterial antibodies and immunoglobulin in sera collected over that time period. In order to help separate the effect of the occupational exposure from that associated with other possible disease pathways, appropriate control groups were utilized. In addition, many of the wastewater workers were recruited into the study at the time of their initial employment in the wastewater treatment industry.

Each quarter blood samples, throat swabs, and fecal samples were collected from participants in the study. Blood specimens were used for the serologic surveys and the throat swabs and fecal specimens were used for analysis for bacteria, viruses and parasites. (Parasitic examinations were performed only during the early period of the study in Cincinnati.) The serologic survey involved the determination of antibodies to a group of viruses and bacteria and measurement of immunoglobulin levels (Table 1). Of concern in the serologic survey was whether the prevalence and level of antibodies were different in the wastewater exposed and control groups, and whether the number of infections as indicated by increases in antibody concentration was different among the various study groups.

Illness information was obtained by monthly health diaries maintained by the workers supplemented by telephone and on-the-job contact. Illness symptom information from all sources was

combined in a manner designed to avoid double counting and was categorized as "respiratory," "gastrointestinal," and "other." The data processing procedures provided for coding various possible combinations of these. The definition of these illness categories was based on the symptoms indicated on the health diary, as follows.

Respiratory	- Cold symptoms, sore throat, cough or other lower respiratory symptoms.
Gastrointestinal	- Nausea, vomiting, diarrhea, or intestinal upset
Other	- Fever, persistent headache, eye inflammation or other eye trouble, earache or other ear trouble, skin infection, rash, boils, or open sores.

From time to time job locations of participants were visited to determine types and levels of exposure and other work conditions. Work site air was monitored periodically for bacterial concentrations, and concurrent wastewater samples at the wastewater treatment plants were analyzed for bacterial and viral concentrations. Six-stage Andersen samplers were used to collect the airborne bacteria. In order to process the air samples as soon as possible, preparation and analyses of the plates for bacterial sampling were performed in Chicago by the Metropolitan Sanitary District of Greater Chicago (MSDGC), in Memphis by the Memphis State University, and by the bacteriologist on the study staff in Cincinnati. All wastewater samples for virus assay were processed by the aluminum hydroxide continuous flow centrifuge technique and assayed by a plaque assay procedure.

On a yearly basis, study volunteers were offered a medical evaluation that included hematology, urinalysis, pulmonary function testing, blood chemistry (including tests of liver and kidney function), and examination by a physician.

A number of comparisons and correlations were made from the epidemiological, environmental, clinical, and serological aspects of the study.

As initially conceived, the study goals were limited to the first three specific objectives listed above. The population groups planned for the study were sewer and highway maintenance workers in Cincinnati. The research design initially called for recruitment of an equal number of men beginning their respective jobs as those recruited who had two or more years experience, for both exposed and control groups. Soon after the study was initiated economic conditions in the municipal government forced a moratorium on hiring new employees in the Cincinnati Public Works Department which eliminated prospects for establishing a newly employed highway maintenance study group.

About one year after this research began, its goals were expanded to include a determination of the health effects associated with the dispersion of aerosols generated by the activated sludge wastewater treatment process (Specific Objectives 4 and 5). At this time the study design was expanded to include two additional exposed population groups: 50 men at the Cincinnati Mill Creek Sewage Treatment Plant which was in the process of being expanded from primary wastewater treatment to include the activated sludge process; and a total of 100 men newly employed at activated sludge treatment plants. Since only one-third of the 100 inexperienced activated sludge plant workers were expected to be available in Cincinnati, the study was expanded to include workers at the plants in Chicago and Memphis. These cities were chosen because at least 50 new employees would be hired within the next year, the plants contained the activated process in open basins with porous plate-type diffusers, they were reasonably accessible to Cincinnati, and the plant administrators were agreeable to the study. MSDGC hired a significant number of new workers because of normal work force turnover by virtue of its size. In addition, its long experience in wastewater treatment and the technical support for monitoring available from its Research and Development Department made it very suitable for study. Memphis was in the final stages of construction of its second activated sludge treatment plant, the North Treatment Plant, an entirely new facility. In addition, its first plant, the Maxson Wastewater Treatment Plant had plans to hire more workers.

Comparison groups in Cincinnati, Chicago and Memphis were highway maintenance water treatment plant workers and gas and electric utility workers, respectively.

## Conclusions

1. Gastrointestinal illness rates were higher in the inexperienced wastewater exposed workers than in the experienced workers and controls. Wastewater workers were not found to be subject to any detectable risks due to parasites present in wastewater. There was only slight evidence, if any, to suggest that there were risks due to viruses and bacteria in wastewater.
2. Immunoglobulin levels were not found to be consistently higher in wastewater-exposed workers than in controls in any of the cities studied.
3. Wastewater workers were not found to serve as a source of viral infections for their family members.
4. In a few instances levels of antibody to certain viruses appeared to be related to level of exposure to wastewater aerosols.
5. Bacterial aerosol levels in buildings where wastewater sludge was being processed were generally higher than levels adjacent to outdoor aeration tanks at the same treatment plants.
6. Since the seroepidemiologic approach did not detect any significant health effects of occupational exposure to wastewater, it is unlikely that this approach would detect potential health impacts in populations with lower levels of exposure to wastewater.

## Recommendations

Since the basic design of this study was to compare antibody levels between two quarters in each year of the study, all sera collected over the entire study period have not been tested. It is possible that changes in antibody levels were not detected by semiannual testing. Selected viruses of high prevalence should be studied by testing all sera for each individual.

Because the predominance of seroconversions to Hepatitis B were in the sewage-exposed groups (seven of 123 sewage-exposed workers compared to one of 52 control workers), additional testing should be done on workers not yet evaluated to determine whether this trend persists.

Additional testing of sera of workers occupationally exposed to soil, such as some sewer and highway maintenance workers, would be useful in attempting to verify previous suggestions that soil exposure increases the risk of infection to *Legionella pneumophila*.

Because of the limited testing of sera for antibody to Hepatitis A, the initial sera of a number of workers has not been tested. It would be useful to test these sera to determine whether any of these people acquired the antibody during the course of the study.

Serologic testing for rotavirus or parvovirus agent was not performed during the study. Since these viruses are now recognized as a major cause of gastrointestinal illness, the sera collected during the study should be analyzed for antibody to them.

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

The complete report, entitled "Health Risks of Human Exposure to Wastewater," (Order No. PB 81-143 406; Cost: \$15.50, subject to change) will be available only from:

National Technical Information Service  
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Springfield, VA 22161  
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