HETA 2000–0397–2863
Littleton/Englewood Wastewater Treatment Plant
Englewood, Colorado

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PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was written by Eric J. Esswein, CIH of the Hazard Evaluations and Technical Assistance Branch (HETAB), Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Denver Field Office, and Edward B. Holmes, MD, MPH, Occupational Medicine Program, University of Utah, School of Medicine, Rocky Mountain Center for Occupational and Environmental Health, Salt Lake City, Utah. Questionnaire data was coded and keypunched by Jenise Brassell and Marian Coleman of NIOSH, HETAB in Cincinnati, Ohio. Desktop publishing was performed by Suzanne Eugster. Review and preparation for printing was performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Chronic Bronchitis Among Employees at the Littleton/Englewood Wastewater Treatment Plant, Englewood, Colorado

In January 2001, NIOSH conducted a study at the Litleton/Englewood wastewater treatmet platn (WWTP) at the request of the Colorado Department of Public Health and Environment to find out if there was a relationship between chronic bronchitis and workplace exposures at the WWTP.

What NIOSH Did

- We reviewed medical records.
- We conducted walkthrough surveys at the plant with management and plant operators.
- We distributed a respiratory health questionnaire to all operations and maintenance employees..
- We reviewed job descriptions and material safety data sheets for chemicals used in the plant..
- We observed employee work practices..
- We spoke with employees and management about present and past working conditions..

What NIOSH Found

- The rate of chronic bronchitis in operations and maintenance employees was roughly the same as in the general population..
- Hydrogen sulfide gas was present in low concentrations in the air within the WWTP.

What L/E WWTP Managers Can Do

- Continue to provide training on personal hygiene practices.

What L/E WWTP Maintenance and Operations Employees Can Do

- Use powder-free latex gloves or vinyl gloves as barrier protection under your leather work gloves to prevent skin exposure to sewage.
- Wash your hands frequently, especially before eating, drinking, or smoking and after removing work gloves.
- Regularly vacuum the floors in your truck cabs to contain and prevent airborne exposures to any materials that get tracked into your truck cabs..

What To Do For More Information:

We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for EPHB Report No. 171-27a

CDC Centers for Disease Control and Prevention

National Institute for Occupational Safety and Health NIOSH

HETA 2000–0397–2748

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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from a representative of the Colorado Department of Public Health and Environment (CDPHE) for assistance in determining if workers' lung problems could be related to exposures encountered while working at the Littleton/Englewood Waste Water Treatment Plant (WWTP). An opening conference and a walkthrough survey were conducted on January 11-12, 2001. Survey monitoring for the presence of hydrogen sulfide gas was conducted. Respiratory health questionnaires were distributed to all current operations and maintenance employees.

Results from the medical respiratory questionnaire indicate that the prevalence of self-reported bronchitis in operations and maintenance employees at the WWTP was similar to that in the general population. At the time of the investigation, the Littleton/Englewood WWTP appeared to be a well-controlled workplace that had implemented a combination of dilution ventilation, managerial controls and, where appropriate, respiratory protection (for certain confined space entry procedures) to protect workers from occupational exposures. Hydrogen sulfide was detected at several locations in the plant, and in the ambient air within the plant. The plant has undergone significant expansion over the years. Changes in work practices at the plant, and improvements in dilution ventilation within the plant, were phased in over a period of time in recent years. These changes were implemented to improve occupational safety and health at the Littleton/Englewood WWTP and appear to be effective at the time of this investigation.

An occupational health hazard was not determined to exist at the Littleton/Englewood WWTP during the time of this investigation. However, occupational exposures to plant operators with a long history of employment would be expected to vary considerably over the years as the plant underwent enlargement and process changes. Workers with many years of employment at this WWTP may have incurred occupational exposures which could cause chronic irritant bronchitis. But at the time of this investigation, evidence of any overall increased risks for chronic irritant bronchitis were not found.

Keywords: SIC Code 4952 (Sewerage Systems), waste water treatment plants, WWTP, sludge.

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INTRODUCTION

In August 2000, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from a representative of the Colorado Department of Public Health and Environment (CDPHE). CDPHE requested assistance in determining whether the cause of chronic irritant bronchitis diagnosed in a former employee of a waste water treatment plant (WWTP) was occupationally related.

BACKGROUND

The Littleton/Englewood WWTP was built in 1953 and employs 64 people. The facility is a primary and secondary municipal wastewater treatment plant. Initially, the plant had a treatment capacity of between 8 and 12 million gallons of wastewater per day (mgd). Over the years, the plant was significantly enlarged. In its current configuration, the plant treats an average of 26 mgd of influent. The majority of the wastewater is residential, but a small percentage (estimated by management to be 1.5 - 3%) of the total permitted load is from hospitals, laundries, metal plating facilities, a dairy, and several other small industries.

Wastewater enters the plant through two 60-inch pipes, one from the city of Englewood and one from the city of Littleton. The influent passes through three mechanically cleaned bar screens which remove large, non-soluble items or debris. Incoming wastewater is pumped to two covered grit basins (for sedimentation) and then to one of four 105' diameter primary clarifying tanks. Clarified primary effluent is then pumped to one of two 105' diameter trickling filters where the effluent is sprayed over trickling surface media (16' in depth) for aerobic digestion. The effluent moves downstream to aerated solids contact basins for further biological treatment to reduce biological oxygen demand, and to inhibit the growth of pathogenic microorganisms by reducing the organic content of the sewage. Secondary sludge is mixed in with the primary effluent in the solids contact basins where the sludge is allowed to age and agglomerate into what is known as "floc." The primary wastewater goes to five final clarifiers where residual suspended materials settle and the clarified waste water is drawn from the top. Sludge is removed from the final clarifiers at the bottom of the tanks and transferred to a sludge collection box. Ammonia removal is accomplished by using nitrifying trickle filters where sodium hydroxide is added to the effluent to oxidize ammonia and remove sulfur compounds. Sludge, collected from the primary clarifiers, the solids contact tanks, and the final clarifiers is pumped to a sludge mixing tank and then to the dissolved air flotation thickeners to remove residual water. Primary and secondary sludge is stabilized (or treated) using anaerobic digestion in four sludge digestion tanks. Anaerobic digestion reduces pathogens in the sludge, reduces the volume, and reduces odors. The WWTP uses two fixed submerged covers and two floating-cover digesters. After digestion, the sludge is centrifuged and dewatered and used as an agricultural amendment. Final effluent passes through one of three chlorine contact tanks, and a dechlorination process before being supplied to the plant water system or to the South Platte river.

A review of a retired employee's medical records indicated that the employee was diagnosed with irritant bronchitis. According to management at the Littleton/Englewood WWTP respiratory health problems effected the employee's ability to perform his job as an operator. He retired in 1999. The employee reported to NIOSH that he spent a lot of time around the sludge digesters and that certain job tasks involved working closely around digesting sewage. The sludge digesters were originally designed with circular floating covers that move up and down as the volume of sludge changed. The covers have seals along their circumference but over time the seals would leak, and foam would spill out onto the top of the

cover. One of the operator's tasks was to break down the foam using either water sprayed from a hose or by using lengths of 2X4" lumber to disperse the foam. Foaming occurred daily for several hours according to management. The WWTP converted all but one of the digesters to fixed covers within the last ten years. According to management, no acute health effects were reported by employees while working at the digesters dispersing foam. In addition to working around the digesters, the employee reported exposures to ammonia, chlorine gas, and the polymer flocculant which is used in the waste waster treatment process.

According to management, WWTP operators perform all operations jobs at the WWTP except maintenance. Operators' tasks include: sampling and monitoring the wastewater stream; evaluating plant and sewage treatment conditions; making changes to valves, pumps and blowers, and performing a variety of job tasks as needed at different locations in the plant during different stages of wastewater treatment. The plant operates on morning shift, mid day, and an evening shift. Management reported that the plant has low employee turnover, with most operators having more than 10 years experience. The WWTP requires that operators be certified through a four-part State of Colorado wastewater treatment plant operator certification program.

Personal protective equipment required for operators includes coveralls or a standard work uniform, safety glasses, and steel-toed boots. A self-contained breathing apparatus (SCBA) is required for certain confined space operations. According to management, dust masks (filtering face piece respirators) are available for use at the discretion of the employee.

The Littleton/Englewood WWTP has undergone significant expansion over the years, including process changes, treatment capacity enhancements, and increases in the amounts of dilution ventilation provided to enclosed work areas such as the headworks building and the filter press area. As a result of the considerable plant modifications and ventilation improvements over the years, it is difficult to assess occupational exposures that may have occurred in the past, compared to the newer plant configuration and processes. For example, all but one of the sludge digesters are now enclosed, and floating lids are not used on three of the four digesters. Dilution ventilation has been increased significantly in enclosed areas, such as the headworks building (when the two influent streams enter the plant), the filter press area, and the area where the floculant is handled.

METHODS

On January 11-12, 2001 a walkthrough survey was conducted for investigators to become familiar with the workplace and observe job activities. Representatives from management accompanied the investigators on the initial plant walkthrough. A second walkthrough was done with two WWTP operators as they made their work rounds on the same day. The initial walkthrough began at the headworks building and followed the process flow to the end of the final water treatment. When the investigators accompanied the two operators on their rounds the operators' tasks included; sampling primary influent, checking and sampling water in the grit basins, sampling the primary clarifiers, inspected the trickling filters, sampling at the solids contact basins, inspecting the sludge digesters, and sampling at the final chlorination area. The operators reported that their routines were standard on that day, with the exception of the headworks building where the solids grinder was down for maintenance. Because solids were accumulating on the bar screen dump, the operator had to remove the accumulating solids manually, with a pitch fork.

Personal air sampling was not conducted on WWTP employees during this investigation for two reasons. First, employees were not known to

be currently experiencing health problems. Second, air sampling would not be representative of exposures considering the significant changes to processes and work practices which have occurred over the years. However, as a screening tool to survey for the presence of hydrogen sulfide (H_2S) gas each investigator wore a recently-calibrated Biosystems Toxilog Ultra real-time H_2S monitor during the walkthrough surveys.

On the morning of the second day of the investigation, medical questionnaires were distributed to employees of the first and third shift. Since not all employees from all shifts could be contacted directly, questionnaires were given to management for employees who were absent or on sick leave or annual leave, or who were away from the plant. Pre- addressed, postage paid envelopes were provided so that the questionnaires could be returned to the investigators. Thirty-five questionnaires were distributed, fourteen to maintenance employees, and twenty-one to operations personnel.

To understand the stated job descriptions for an operator and a supervisor, NIOSH reviewed both current and past job descriptions. Job descriptions for Plant Operator I and II, Wastewater Operations Superintendent, and Operations Division Manager were received and reviewed dating back to at least 1980 (some were undated) and up to the year 2001.

In-house accident and injury logs dating back to 1990 were also reviewed as part of this investigation. Additionally, copies of selected Material Safety Data Sheets (MSDSs) were requested from the WWTP Safety and Health Manager for review. MSDSs were requested for those products or chemicals used at the plant by the operators.

Occupational Health Hazards of Sewage Treatment Workers

Individuals working in WWTPs have risks for exposure to a wide variety of different microbiological agents and chemicals.[1] The type and quantity of contaminants entering sewage treatment plants can vary considerably depending on the source of the influent, the volume of the influent, and the time of day. Biological exposure health risks include: enteric viruses such as enteroviruses, rotaviruses, and Hepatitis A. Bacteria including Escherichia coli, Shigella, Salmonella, and Tetanus, protozoans, Leptospira, and endotoxins from Gram negative bacterial cell walls. Chemical exposure health risks can include: volatile organic compounds (generally when the influent contains industrial wastewater), carbon monoxide, chlorine, ammonia, methane, hydrogen disulfide (H_2S), nitrogen, and carbon dioxide.

Some epidemiological studies of wastewater and sewage workers have shown an increased risk of gastrointestinal symptoms.[2,3,4,5,6] Lundholm and Rylander found that skin disorders, diarrhea, and other gastrointestinal symptoms were more prevalent among employees at six Swedish wastewater treatment plants than among workers at three water treatment plants.[7] Scarlett–Kranz and associates also found that sewage workers in New York reported a significantly higher frequency of diarrhea, dizziness, headache, skin irritation, and sore throat than workers at water treatment plants.[8] Zuskin et.al. found that rates of chronic respiratory symptoms (e.g, chronic cough, phlegm, chronic bronchitis and chest tightness) were higher in a group of sewage workers who performed their jobs in confined and poorly ventilated areas (e.g., sludge digesters, and pumping stations) compared to controls, or those who worked in more ventilated areas. In the same

study, baseline ventilatory capacity was significantly decreased compared to predicted values in the sewage workers, suggesting obstructive changes in the small airways. No definitive exposure was reported[9].

A study investigating whether H_2S exposures to sewage workers was associated with lung function reported reduced lung function when comparing sewer workers to water treatment plant workers.[10] An investigation in 1999 quantified airborne endotoxin concentrations in eight sewage treatment plants, performed spirometry and airway responsive examinations on workers and reported that rates of symptoms (nasal irritation, tiredness, joint pains, and diarrhea) were higher for sewage workers than the control population that was studied. Personal breathing zone exposures were not measured in this investigation, but the authors reported that high endotoxin concentrations were a suspected exposure for the reported health effects.[11] A recent study investigating community environmental exposures to H_2S reported that interviewed community members in towns and cities known to have chronic low-level environmental exposures to H_2S reported significantly higher central nervous system, respiratory, and blood system symptoms than individuals in reference communities that did not have chronic low-level environmental exposures to H_2S.[12]

Sewage workers can be exposed to gram negative bacteria via inhalation of aerosolized microorganisms, by hand-to-mouth contamination, and possibly, by accidental ingestion of liquid waste. Bacterial endotoxin is present in sewage. Bacterial endotoxin is a lipopolysaccharide compound from the outer cell wall of Gram–negative bacteria, which occur abundantly in organic dusts.[13] The biological properties of endotoxin vary depending upon the bacterial species from which they are derived, as well as upon the state of the growth cycle of the bacteria.[14] Endotoxin exposure can cause fever and malaise, changes in white blood cell counts, respiratory distress, shock, and death. Endotoxin can also act as a stimulant to the immune system.[15,16]

Sewage treatment workers can be exposed to hydrogen sulfide (H_2S) because the gas is a common byproduct and an odor problem inherent in WWTP processing. Hydrogen sulfide is produced when anaerobic bacteria convert sulfates in wastewater (particularly in sewer slimes and sludge) to sulfides.[17] The amount of H_2S which is produced can vary with temperature, long transit times, low pH, concentrated or strong sewage and, anaerobic conditions in the pipe wall slime.[18] H_2S is a strong mucous membrane, respiratory tract irritant, and a chemical asphyxiant. H_2S has a very distinctive and characteristic odor which is often described as "rotten eggs." Eye irritation can occur at levels of 10-20 ppm and at high exposures (around 100 ppm) H_2S can inhibit the respiratory tract causing death from respiratory arrest.[19]

A study conducted in 1995 investigated sewage treatment workers and compared their health with water treatment plant workers. A difference in pulmonary function (the ratio of FEV1 /FVC) was found between non-smoking sewer workers (with presumed high H_2S exposures) and the water treatment control workers. There were no differences between the two groups in the sewer workers that were presumed to have low to medium exposures to H_2S. In this same study, a trend of decreasing lung function was reported those workers with increasing years of employment and moderate and high levels of H_2S exposure. [10]

RESULTS/DISCUSSION

Workplace Observations

During the walkthrough survey the Biosystems H_2S monitors worn by the investigators registered 3-4 parts per million H_2S outside while standing

next to the primary clarifiers. On one occasion as the investigators left the parking lot in front of the administration building go into the plant, the monitors alarmed simultaneously. The monitors had been set to alarm at a ceiling concentration of 10 ppm. This indicated that a brief, instantaneous concentration of at least 10 ppm of H_2S was present in the air. This gas likely originated from the primary clarifiers as the investigators noted that they were directly downwind from the clarifiers when the monitors alarmed. Other areas where H_2S was detected included the trickling filters. When a monitor was held just inside the access door to the #1 unit, twenty-two ppm of H_2S was detected. Three ppm was detected outside the same door on the steel grating walkway. Inside #2 trickling filter the concentration of H_2S was below the limit of detection of one ppm. A minute later one ppm of H_2S was detected outside the enclosure of the trickling filter. It is important to note that the area inside the doors of trickling filters is considered a confined space and operators do not enter this area without respiratory protection.

Two peak concentrations were measured by the H_2S monitors during the walkthrough with the operators. The monitors indicated that peaks of H_2S corresponding to 22 ppm and 3 ppm occurred at some time during the walkthrough survey .

Job Description Reviews

Job descriptions for a Plant Operator I (dated 1980) described working conditions/hazards as follows: "Employee must work in a plant facility where machine noise, dust, dirt, oil and irritants are always present." Another description (undated) described working conditions/hazards as: "The operator works is a heavily industrialized environment and will be continually exposed to one or more of the following: inclement weather, dust, dirt, oil, skin irritants, loud noises, dangerous materials, and moving machinery." More recent Position Descriptions included an Occu-Med Job Profile (dated April 1996) that described the environmental factors for a Wastewater Operator as: regular work with or around potentially harmful substances (may include pesticides, degreasing cleaners, lead, sulfuric acid etc). The job descriptions for Supervisor indicated that the job is an office-based position but also lists exposure to potentially harmful substances (the same one listed for an Operator) on the Occu-Med profile.

The MSDSs's which were provided to NIOSH by the WWTP included the following: Ferric Chloride, drinking water grade (aqueous ferric chloride), Percol 757 (flocculant) which contained adipic acid, an acrylamide co-polymer, and water. Sodium bisulfite solution, Caustic Soda (sodium hydroxide) and Sodium Hypochlorite Solution.

Medical Questionnaire Results

The questionnaires response rate was 33 of 35 or 94%, including 13 in maintenance and 20 in operations. All employees were male. The clerical and janitorial staffs working in the administrative building were not sampled. A sample questionnaire is included in Appendix A.

Ninety-one percent of the respondents (30 of 33) reported they worked on a roving schedule throughout the entire plant. Two employees reported that they worked primarily in the office area and rarely made trips to the sewage treatment area of the plant. One employee reported working only in the dewatering area. Employees all reported working full time. The average number of hours worked per week was reported as 40.4 hours, the median and mode were both 40, and the range was 40-45 hours. The mean number of years worked at the WWTP was 12.1, the median was 13.2 and the mode was 2.2. The range for years worked was 0.5 to 25 years. The average number of years worked in their present position was 8.6, the median was 6.8 and the range was 0.3 to 25 years.

Eighty-one percent of the employees were white,

9% Hispanic, 3% Asian, 3% American Indian and 3% other. None of the respondents mentioned bird keeping or farming as hobbies or activities. This question was asked because these activities can result in exposures which can cause or contribute to lung disease. Five of 33 (15%) respondents mentioned they do welding at least occasionally.

For purposes of determining prevalence rates, the data were evaluated using a case definition for chronic bronchitis as occurrence of cough, productive of phlegm, on most days for more than 3 months in the year, for at least 2 successive years.[20] Using this definition, chronic bronchitis was reported by 4 of 33 or 12.1% of the respondents. The prevalence was 15.3% in maintenance and 10% in operations. Both maintenance and operations employees work throughout the whole plant, however maintenance employees could be in one part of the plant for an extended time period if they were involved in a lengthy repair project. Operations personnel tend to rotate throughout the plant while making their rounds.

Four of 33 (12%) of the respondents reported ever having asthma. Ten of 33 (30%) reported a current complaint of wheeze or chest tightness. Of those employees who reporting wheeze or chest tightness, only 1 in 10 (10%) related this symptom to work. Six of ten (60%) employees reported that they were unsure if they could relate this symptom to work.

Eight of thirty-two (25%) of the employees reported that they were current smokers. Eleven of 32 (34%) of the employees reported that they were smokers in the past. Thirteen of 32 (40.5%) reported they never smoked. None of the eight employees who were smokers reported symptoms suggestive of chronic bronchitis; one employee reported a physician diagnosis of asthma. The 4 employees reporting symptoms consistent with chronic bronchitis currently were all non-smokers; one was a past smoker. In this small sample, the prevalence of symptoms suggestive of chronic bronchitis was greatest (23%) in the non-smokers. It is unreasonable to conclude that cigarette smoking is a protective effect against chronic bronchitis and asthma for smokers who work in wastewater treatment plants. The more reasonable conclusion is that the small numbers in this study do not allow for any inference or clear conclusion because the numbers of smokers in the sample is simply too small.

The prevalence of chronic bronchitis in the general population is difficult to estimate. One investigation found between 20 and 40% of men (8-20% of women) reported symptoms of phlegm production consistent with bronchitis.[21] The prevalence of wheezing or asthma like symptoms is estimated to be about 10%. Between 8% and 18% of American men described symptoms of wheezing in a study by Lebowitz[22] et. al.. Some occupational health investigations of sewer workers have found an increased incidence of chronic cough, chronic sputum production, chest tightness and throat irritation but not pulmonary function abnormalities.9 It is well known that workers in dusty trades have an increased prevalence of bronchitis.

Responses to the respiratory symptom questionnaire administered at the Littleton/Englewood WWTP show that the prevalence of chronic bronchitis among the current workers at the WWTP is no higher than the prevalence of chronic bronchitis-like symptoms in the general population.

It is important to mention that the investigation had some limitations, one was the small sample size, another was the cross-sectional nature of the study (in other words, a point in time investigation,) however there was good participation for the medical questionnaire. This study looked only at current employees in this workplace and a comparison or control population of workers was not studied. Bias from awareness of and concern about health conditions involving workplace exposures could influence reporting of complaints on a questionnaire, but

this normally leads to over-reporting which was not the case in this investigation.

Determining causality for bronchitis can be quite challenging because the disease has multiple causes. Both occupational and non-occupational factors can affect or aggravate symptoms of this disease. While bronchitis is a disease with a very specific diagnostic criteria, irritant bronchitis is non-specific in terms of causality. That is, exposure to a wide variety of respiratory irritants could act as triggers for symptoms of bronchitis, and many of these irritants such as chlorine, ammonia, and airborne dusts are present at WWTPs.

CONCLUSIONS

Sewage treatment workers have risks for exposures to chemicals including ammonia, chlorine and hydrogen sulfide. Materials such as organic dusts, microbiological organisms such as bacteria and fungi, and byproducts of these organisms such as endotoxin also present exposure risks for operations and maintenance workers at wastewater treatment plants. The medical literature supports an association between sewage treatment plant workers and the presence of increased respiratory symptoms, and respiratory health effects for employees who work at WWTPs.

During this investigation, the Littleton/Englewood WWTP appeared to be a well controlled workplace that had implemented a combination of dilution ventilation, managerial controls and, where appropriate, respiratory protection (for certain confined space entry procedures), to protect the workers from occupational exposures. However, workers with a long employment history at this WWTP reported that in the past, the workplace was not as well controlled as it is now. Changes to process operations, increases in the volume of effluent treated per day, and differences in ventilation in various locations of the WWTP over the years suggest that the condition of the WWTP at the time of this investigation was not the same as it was in the past. Workers with many years of employment at this WWTP may have incurred occupational exposures which could cause chronic irritant bronchitis. But at the time of this investigation, evidence of overall increased risks for chronic irritant bronchitis was not found.

RECOMMENDATIONS

The following recommendations are provided in the interests of helping to maintain a safe and healthy workplace at the Littleton-Englewood WWTP.

- Employees who wear protective leather gloves while performing jobs that have the potential for exposure to raw or in-process effluent should wear powder-free latex, vinyl, or another suitable barrier protection glove underneath their leather gloves.

- The floors of truck cabs should be vacuumed out on a regular basis to reduce the risks of potential inhalation exposures to tracked-in contaminated materials which could become airborne by the force of air from the truck's heating, cooling and ventilation system.

- Periodic training regarding standard hygiene practices should continue to be conducted by reviewing issues such as the necessity for frequent and routine hand washing. This is the most valuable safeguard in preventing employee exposure to infectious agents present in sewage.

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