



Project Summary

Epidemiological Study of *Klebsiella pneumoniae* Among Pulp and Paper Mill Workers

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In a one-year study fecal coliform and *Klebsiella* bacteria densities were measured in several of Wisconsin's pulp and paper mill processing wash waters, treated waters, and waters receiving pulp and paper mill effluent discharge. The isolation of fecal coliform bacteria ranged from as low as a minimum detectable level of less than 10 organisms/100 ml water sample to as high as an estimated 5×10^6 organisms/100 ml water sample. Water data were obtained from an effluent survey of twenty plants and a within-plant survey of three mills. These findings support previous investigations concerning the selective growth of coliform bacteria in pulp and paper mills utilizing processed water recycle loops.

Biochemical testing revealed that over 50 percent (range from 4 to 97 percent) of the fecal coliform bacteria associated with pulp and paper mill processing were identified as bacteria of the genus *Klebsiella*, of which *K. pneumoniae* was found to be the most prevalent species.

Sampling of paper mill workers resulted in *Klebsiella* isolation from the upper respiratory tract. *Klebsiella* biotyping revealed that the *Klebsiella* isolation from a pulp mill worker matched the *Klebsiella* biotype found in the plant's processing waters. An additional relationship was observed between *Klebsiella* biotypes isolated from plant sanitary sewers and the mill's processing waters.

There is a strong suggestion that upper respiratory tract colonization, with potential health hazards, can occur in pulp and paper mill workers occupationally exposed to *Klebsiella* bacteria. *K. pneumoniae* has been identified as the predominant coliform bacterium from such an industrial waste source and is responsible for 2 percent of the bacterial pneumonia cases in the susceptible population of the United States and 60 to 70 percent of the deaths attributed to this disease. Recycling or reuse of water within the pulp and paper industry has been shown to enhance proliferation of *K. pneumoniae* densities. Until further research to assess the health risks of populations exposed to water contaminated with *Klebsiella* is carried out, the U.S. Environmental Protection Agency should not encourage recycling within the pulp and paper industries as a means of reducing waste discharges.

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

Industrial organic wastes from pulp and paper mill effluents and their treatment facilities have been known from

previous studies to generate high numbers of coliform bacteria. *Klebsiella pneumoniae* has been isolated and identified as the predominant coliform bacteria from such an industrial waste source. *K. pneumoniae* is responsible for 2 percent of the bacterial pneumonia cases in the susceptible population of the United States with 60-70 percent of the deaths attributed to this disease.

Recycling or reuse of water within the pulp and paper industry has been evaluated with respect to coliform densities in various mill systems and has been shown to be selective for bacterial proliferation especially with regard to *K. pneumoniae* densities.

It was the purpose of this study to determine first, the fecal coliform and *Klebsiella* bacteria distribution in Wisconsin's pulp and paper mills, and second, because of the potential health risk, to determine if workers employed in pulp and paper mills have significantly greater colonization of *Klebsiella* than workers employed in nonpulp and paper industries.

Discussion

In general, the results showed that the level of fecal coliform bacteria present in influent waters supplying paper mills, as measured by the standard fecal coliform indicator test, was significantly lower than the fecal coliform counts being discharged from plant effluents. In two out of the three mills sampled, the influent water source had minimum detectable levels of fecal coliform bacteria (i.e., less than 10 organisms per 100 ml) whereas effluent water discharged had high levels of fecal coliform bacteria, ranging from 270,000 to an estimated 2×10^6 organisms per 100 ml. Since *Klebsiella* was the predominant coliform bacteria identified as giving positive fecal coliform response, it may be postulated that *Klebsiella* proliferating early in the pulp processing stages may be responsible for the elevated fecal coliform levels discharged from plants in the final effluent. The study observations give supporting evidence for *Klebsiella* maintaining a possible wood or bark reservoir since influent water supplying the three sampled mills had no detectable *Klebsiella* levels. However, once raw wood combined with distilled phosphate buffer was sampled from each plant, *Klebsiella* was consistently isolated.

Thus, once *Klebsiella* proliferated

from the early pulping stages, the reuse of water within the plants aided in maintaining elevated bacterial levels through each plant's treatment stages. Wastewater treatment could not significantly reduce the *Klebsiella* nor total fecal coliform levels.

The goal of a fecal coliform indicator implicitly refers to a restricted group of microorganisms specifically and exclusively associated with fecal wastes. However, the study findings indicate that such is not the case because of the significant proportion of *Klebsiella* bacteria isolated from pulp and paper mill processing waters having no apparent fecal source. The fecal coliform test selects for bacteria primarily of the genus *Escherichia* but because of the test's lack of specificity, other bacteria including *Klebsiella*, *Citrobacter*, and *Enterobacter* give positive reactions as well. Because of *Klebsiella*'s tremendous "regrowth" potential in waters contaminated with pulp and paper mill waters, there is an increasing need for reevaluating the validity of the fecal coliform test as an indicator in these types of industrial wastewaters.

Since *Klebsiella* is not exclusively or specifically associated with fecal waste, the study findings recommend that highly specific indicators of fecal waste contamination, such as *E. coli*, be used

as indicators of fecal contamination, thereby eliminating the interfering response of *Klebsiella* bacteria from a nonfecal source.

Further study is needed in the evaluation of the health effects in workers exposed to high levels of *Klebsiella* in the workplace. The study findings indicated that paper industry processes selectively allowed *Klebsiella* to grow and in levels exceeding the only water contact standard promulgated - i.e., fecal coliform levels cannot exceed 200 organism per 100 ml. *Klebsiella* and fecal coliform bacteria were present in levels as high as an estimated 2×10^6 organisms per 100 ml where exposure to any worker involved in the mill processing could occur. Although no significant relationship was found for *Klebsiella* colonization in paper workers, there is a strong suggestion that upper respiratory tract colonization can occur. Larger sample size evaluation with subsequent infection follow-up may answer the question of potential health hazards to pulp and paper mill workers occupationally exposed to *Klebsiella*. Until these studies are carried out, it would be prudent that the U.S. Environmental Protection Agency not encourage recycling in the pulp and paper industry as a means of reducing waste discharges.

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The complete report, entitled "Epidemiological Study of *Klebsiella pneumoniae* Among Pulp and Paper Mill Workers," (Order No. PB 81-172 298; Cost: \$9.50, subject to change) will be available only from:

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